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Joint Warfare Simulation Object Library

Joint Warfare Taxonomy

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FOREWORD

Clearly, the focus of U.S. military training has become joint warfighting. Just as clearly, planning and operating with armed forces of different services and philosophies will introduce Joint Force Commanders and staffs to situations they have never seen, nor thought through. They must be trained—with simulations, wargames, and exercises—*not* on the battlefield. Exercises are expensive in dollars and manpower. Joint simulations and wargames must be granted priority.

From my perspective as a former unified command Director for Operations, the Joint Warfare Simulation Object Library approach is on the mark. It offers a route to consistent joint modeling that can carry the warfighter into the next century.

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EXECUTIVE SUMMARY

The Joint Warfare Simulation Object Library (JWSOL) applies object-oriented analysis and design to modeling theater-level joint operations. JWSOL will be a repository of reliable, robust, reusable warfare simulation classes and objects that can be used to:

- Develop and populate a wide range of joint models and scenarios,
- Support interoperation of both new and legacy models and simulations.

PROGRAMMATIC GOALS

1. Jointness. JWSOL will go beyond "multi-service" interoperability to include true joint command and control (C^2) and procedural elements.
2. Communication, cooperation, and collaboration. A common library of reusable software objects will foster interorganization communication, cooperation, and collaboration.
3. Reuse. Time-to-field, reliability in the field, and monetary constraints all argue for reuse. JWSOL will support software reuse at all levels—conceptual, analytic, design, and eventually code, documentation, and verification and validation (V&V) test cases.
4. Results. Recent changes in threat and budget have focused the military on the efficient use of commercial products. JWSOL will use commercial object-oriented languages and platforms, and comply with commercial standards for documentation and support whenever possible.

TECHNICAL GOALS

Four near-term and six long-term technical goals for JWSOL are described below.

Near-Term

1. Complete detailed design; complete specification of objects. During the second phase of the JWSOL project, object specifications for the warfare objects defined in the first phase will be developed. These specifications will be captured in an object model developed and documented with object-oriented design (OOD) Rumbaugh software. The object specifications will be developed through an iterative process of prototyping and documenting. Iterations will continue until the entire set of objects, with their related inheritance hierarchies and "part of" hierarchies, come together in a final design. That design will be documented iteratively and readily coded from the specifications. Subject matter experts (SMEs) will continue to support evaluation during the development of the object specifications.
2. Monitor and incorporate evolving commercial and government standards. Progress of commercial standards, such as the Object Management Working Group (OMWG) Common Object Request Broker Architecture (CORBA) will be monitored. Standards will be understood and incorporated throughout the design and development of JWSOL objects to ensure compatibility with commercial object-oriented products.
3. Continue relationships with collaborative programs. Coordination with collaborative programs will continue. Relationships have been established with the Joint Task Force–Advanced Technology Demonstration (JTF-ATD), OMWG, Naval Simulation System (NSS), Joint Simulation System (JSIMS), Dynamic Environmental Effects Model (DEEM), and Joint Warrior Interoperability Demonstration–95 (JWID–95) programs. Continued participation by JWSOL personnel in working groups associated with these programs will provide the necessary feedback to ensure the success of JWSOL.

4. Build prototypes, deliver to programs, and perform beta test analysis. The third phase of JWSOL will complete the prototype integration of commercial off-the-shelf (COTS) and government off-the-shelf (GOTS) features and concentrate on the test and evaluation of the library features. Operator and user documentation will be delivered. The library will be filled with validated objects and the first deployments will be made. At the end of this phase, the JWSOL capability will transition to life-cycle maintenance.

Long-Term

1. Extend JWSOL to other warfare and operations other than war areas. A natural customer-driven extension of JWSOL is to more levels of operations and more kinds of operations. The structure of the taxonomy is favorable to such extension.
2. Extend JWSOL to multiple levels of resolution. Multiple resolution is a difficult ongoing problem for modeling and simulation (M&S). Possibly using the concept of perspectives, JWSOL will be refined to offer multiple levels of resolution on demand. This would apply to multiple interfaces, multiple attributes, and multiple methods, satisfying the levels of resolution necessary, as defined by customer demand.
3. Integrate knowledge systems technology into JWSOL. Several available public-domain knowledge systems tools might be integrated into JWSOL; C Language Production System (CLIPS), Knowledge Representation Specification Language (KRSL), and Knowledge Acquisition and Design Structuring (KADS) are three examples. Also, knowledge visualization efforts are going on in many places in the military; the Naval Underwater Warfare Center and Rome Laboratory are two research sites. Knowledge systems tools and knowledge visualization capabilities will be integrated to facilitate explicit, user-modifiable strategy and tactics modeling, as well as, deeper representation of C^2 decision making.
4. Construct sample models and applications. Sample model components, models, and applications will be constructed using JWSOL classes and objects. These are valuable aids to programmers new to JWSOL in that they provide guides to model construction. Use of sample programs is standard in commercial software tool publishing.
5. Pursue possible crossover with JTF–ATD OMWG C^2 Schema. The OMWG C^2 Schema effort, discussed in section 3.4, has been closely coordinated with the development of the JWSOL Taxonomy. The OMWG C^2 Schema will evolve based on its customer's needs and the rate at which it is fielded. JWSOL covers areas that the OMWG is not intended to support; but, for common ground, the potential exists for productive interaction. Design and implementation elements from OMWG will be incorporated where necessary to better support JWSOL users.
6. Integrate validated classes and objects into an Information Analysis Center (IAC). Development, implementation, documentation, configuration management, verification, validation, and accreditation (VV&A), and support activities will be performed to make the JWSOL repository suitable for incorporation into an IAC.

The analysis and taxonomy presented in this document will satisfy both near- and long-term goals.

OVERVIEW

JWSOL published the JWSOL Requirements Document in August 1994. The taxonomy described in this report is the product of an object-oriented analysis of those requirements.

JWSOL sees the world through the eyes of a theater Commander-in-Chief (CINC). This perspective was chosen because the CINC is the center of joint operations, and the challenge of analyzing truly “joint” C^2 and procedures at a level above multi-Service interoperability rests at that level.

The taxonomy must organize a large amount of heterogeneous material, and it is meant to be a general framework within which even more material can be integrated. The taxonomy provides a general high-level framework within which greater, more refined decomposition of classes can occur. The Theater CINC and JTF Commander represent the theater strategic level of war, a level at which operations are conceived, planned, and coordinated in a truly joint context. The operational and tactical levels of war, however, remain the domain of the component Services. “Jointness” at these levels of war is determined by the adaptability of software objects for use and reuse in varying resolution in both joint and component Service M&S.

To illustrate, at theater level, the allocation and apportionment of air power, campaign planning, and development of the air tasking order (ATO) are the main concerns of the Joint Force Air Component Commander (JFACC), the Air Operations Center (AOC), and the CINC. To perform these high-level functions, objects representing targets, aircraft, munitions, personnel, and airspace control measures are not really necessary. Lookup tables of aircraft readiness and other information can provide adequate information to the ATO plan object; however, to facilitate “jointness in simulation,” the JWSOL taxonomy also will include intervening component Service C^2 structures and processes, as well as specific combat, support, and logistics equipment objects necessary to actually complete the mission “thread” from ATO to time-on-target.

At the top level, the basic categories are Physical, Event, and Agent. They are tied together in Command and Control.

Physical includes military assets (ships, boats, planes, satellites, communications equipment, supplies, etc.), and physical infrastructure (bases, railroad depots, airfields, roads, bridges, etc.). The Environment is also classed under Physical.

Event has three major subclasses: Military Event, Civilian Event, and Environmental Phenomena. Environmental Phenomena includes important, but transitory events, e.g., hurricanes, floods, and earthquakes, which are occurrences in nature rather than things in nature. It also includes (as a distinct subclass) “conceptual environmental objects”—things that exist in the environment by agreement, such as borders, shipping lanes, airways, and assembly areas.

In the past, events were not usually directly represented in the classification hierarchies of object systems; however, very recent thinking in the field has legitimized and promoted events as classes [9]. In the military context, it is not difficult to think of categories of events with distinct attributes and behaviors.

Agent is the third major class. Agents initiate actions to pursue goals. An Agent is anything that can properly be said to have goals, desires, motivation, intentions, and plans. Humans and organizations are the most important things in the military. “Agency” is their core unifying idea.

Human and Organization are linked using an association class, Role. Elements that exist in a person’s relationship to an organization, like title, rank, seniority, and assignment are represented in Role.

Finally, *Command and Control* is the association class that links Physical, Event, and Agent. Command and Control unifies the people and organizations, the materiel, the missions, the environment, and the status of all of these in Missions and Information Products—the Plans, Orders, Situation Reports, Messages, Specified and Implied Tasks, etc., used by military commands.

Figure E-1 shows a simplified view of the top-level classes and their relationships. Section 7 and appendix A reiterate and elaborate this view in greater detail.

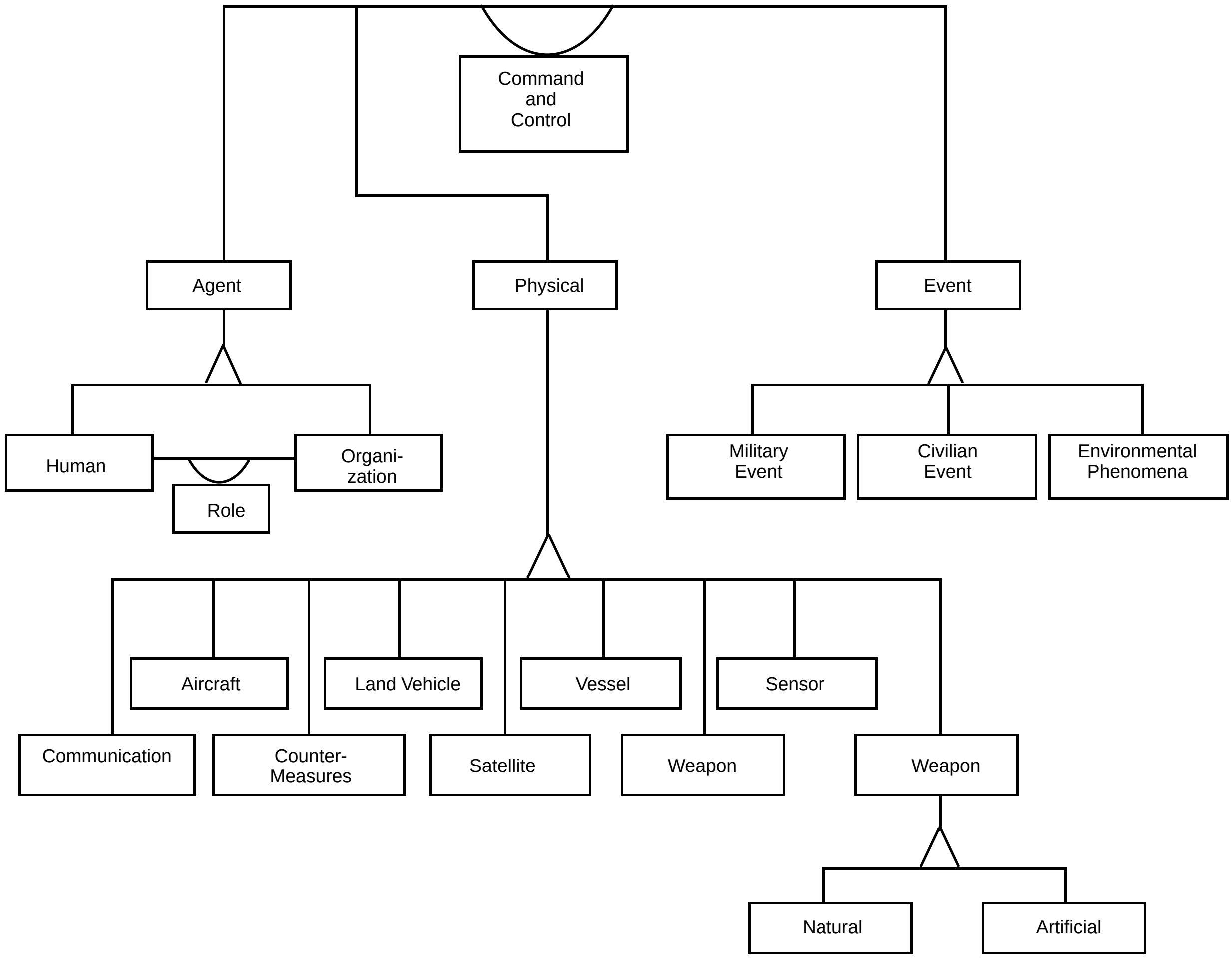

Figure E-1. The top level of the taxonomy unifies materiel and environment, events, and people and organizations, seen from the point of view of a CINC. The half circle above command and control represents an association relationship that Agent, Physical, and Event have with Command and Control.

No single taxonomy will encompass all possible M&S needs at all levels of representation and resolution. Thus, an implicit requirement for JWSOL is to fit as seamlessly as possible with other evolving taxonomies, such as the JTF–ATD C^2 Schema, the NSS taxonomy, and the Multiwarfare Assessment and Research System (MARS) domain representation. JWSOL and related programs should be mutually supportive and co-evolving, each contributing perspectives and expertise to the others so that all can mutually benefit. Every effort must be made to have different perspectives and taxonomic proposals for achievement of common goals to work cooperatively.

CONTENTS

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1. INTRODUCTION

The Joint Warfare Simulation Object Library (JWSOL) applies object-oriented analysis and design to modeling theater-level joint operations, including classes for theater warfare and operations other than war. A repository of reliable, robust, reusable warfare simulation classes and objects will be developed that can be used to:

- Develop and populate a wide range of joint models and scenarios.
- Support interoperation of both new and legacy models and simulations.

JWSOL sees the world through the eyes of a theater Commander-in-Chief (CINC). This perspective was chosen because the CINC is the center of joint operations, and the challenge of analyzing truly “joint” command and control (C^2) and procedures at a level above multi-Service interoperability starts at that level.

1.1 MOTIVATION

Military activities are increasingly conducted in a joint environment. This revolution in military activities has been brought about by reductions in military funding and resources and by growth in heterogeneity of threats that may be confronted.

Much of the “joint simulation” development today is really Service-specific simulations of how function and activities will be carried out independently when more than one Service participates in an operation. This approach will become increasingly unproductive.

Robust simulation objects and a comprehensive simulation framework, with Distributed Interactive Simulation (DIS) and Common Object Request Broker Architecture (CORBA) compatibility, will improve the power of future simulations while simultaneously cutting costs and reducing time-to-field.

1.2 CURRENT CHARACTER OF JWSOL

JWSOL, as represented in this document, is a proposal for general-purpose modeling and simulation taxonomy at the theater level.

Several projects are addressing the use of object technology (OT) in modeling and simulation (M&S). An important need in traditional M&S, recognized by the Defense Modeling and Simulation Office (DMSO), is to provide a common language before fragmentation and a “not invented here” syndrome develops. However, although JWSOL is a response to this need, it is not the only response. JWSOL in its current state is not the “final word” in warfare class hierarchies.

Rather, a group of subject matter experts (SMEs), working in an environment designed to provide a great deal of freedom of conception, has attempted to represent the domain clearly and simply. A great debt is owed to projects like the Multiwarfare Assessment and Research System (MARS) and the Navy Taxonomy that preceded JWSOL, and to the Joint Task Force–Advanced Technology Demonstration (JTF–ATD) C^2 Schema (especially to the Data Server work), which is evolving concurrently.

Ideas have flowed freely between projects. It is important to recognize that JWSOL has been able to proceed without the intense implementation concerns that influence the Naval Simulation System (NSS), MARS, and the JTF–ATD C^2 Schema. Thus, the design team has been free to conceive the domain without strong “local” constraints. The proposal put forth in these pages reflects that freedom.

It is hoped that JWSOL will contribute productively to the evolving M&S community-wide consensus on reusable class taxonomies. Naturally, the authors of JWSOL believe that it is a powerful framework and starting point. But the bottom line is use. That will only come with debate, compromise, consensus, and a principled merging of top-down and bottom-up issues in taxonomic representation.

1.3 JOINT WARFARE TAXONOMY

This document is a review draft of the JWSOL object taxonomy. The sections leading up to section 7 provide context; the sections after discuss plans and provide reference material. Section 7, the Taxonomy Hierarchy, and appendix A, the Rumbaugh presentation of the taxonomy, are the heart of the document, and of the work to date.

Section 2 discusses the goals of the JWSOL program. Section 3 describes the potential uses and the users of the capability. Section 4 reviews the status of JWSOL and briefly summarizes some related programs. Section 5 summarizes the requirements detailed in the August 1994 JWSOL Requirements Definition document, and discusses some further requirements for an effective object repository. Section 6 provides a quick review of important concepts of object technology, introduces the taxonomic notation, and discusses interoperability, the Model Request Broker, and the role of JWSOL in supporting both. It also portrays some of the technical difficulties in developing a taxonomy. Section 7 is the annotated taxonomy. Section 8 summarizes the current and projected plans for the JWSOL project.

2. GOALS

This section discusses JWSOL's programmatic and modeling and simulation goals. JWSOL's programmatic goals are overarching goals that ensure JWSOL meets emerging requirements of the force as a whole. JWSOL's M&S goals are broad-based technical goals that influenced the JWSOL analysis and specific technical goals that JWSOL attempts to satisfy. Following these discussions, JWSOL's relationship to the DoD master plan for M&S is discussed.

2.1 PROGRAMMATIC GOALS

2.1.1 Jointness

JWSOL established four programmatic goals: (1) jointness; (2) communication, cooperation, and collaboration; (3) reuse; and (4) results. Future U.S. military operations will require an increase in both the number of joint exercises and operations and the degree to which real joint command and control will be present. Previously, the focus of modeling and simulation efforts has been on planning, acquisition, and training approaches of the individual Services. Now, however, joint activities have come to the forefront.

2.1.2 Communication, Cooperation, and Collaboration

For the military as a whole, evolving missions combine with increasingly tight budgets to force more interorganization communication, cooperation, and collaboration—both within and across Services. JWSOL will provide common resources and languages for interaction.

2.1.3 Reuse

Time-to-field, reliability in the field, and monetary constraints make reuse important. JWSOL facilitates reuse at all levels—conceptual, analytic, design, and eventually code, documentation, and verification and validation (V&V) test cases. This is supported by the use of object technology (OT); extensive documentation of requirements and analysis, along with the rationale for design choices; use of standard notation to express an analysis; and representation of the results of the analysis in both book and electronic (ParadigmPlus) form. Also, the active involvement of JWSOL personnel in related projects such as the Advanced Research Projects Agency (ARPA) JTF–ATD Object Modeling Working Group (OMWG) and the Navy Simulation System (NSS), has served to develop a unified joint approach to the problem domain that should also favorably affect or encourage reuse.

2.1.4 Results

The JWSOL approach is oriented toward results-based modeling of joint operations. Several practical and cost-effective technical advantages derive from this; the most important is the development of JWSOL using commercial object-oriented languages and platforms.

2.2 MODELING AND SIMULATION GOALS

The broad-based technical goals for M&S that influenced the analysis and the specific technical goals that JWSOL attempts to meet are discussed below.

2.2.1 Broad-Based Technical Goals

There are three important trends in M&S:

- Interoperaility, both among new developments and between new and legacy systems.
- Consistency and intelligibility of domain representation.
- Flexibility and extensibility.

As a library of common objects, JWSOL will promote interoperation of new models and simulations in the simplest possible way—by providing common representations, behaviors, and interfaces for a range of warfare objects. Also, JWSOL will provide a "language" and an interface specification for interaction with new (JWSOL-compliant) models. To accomplish this, several technical requirements are implied:

- Platform and language interdependence.
- Simulation engine architecture and approach independence.
- User environment independence.

Consistency and intelligibility are critical for credibility, widespread acceptance, and correct use. The fundamental approach of JWSOL has been to adhere to a "natural" structure based on the cognitive processes and realities of users of the domain. All classes and objects in JWSOL directly and unambiguously represent real-world objects. To resolve any question regarding JWSOL classes or objects, the real-world analog is definitive.

JWSOL has two constraints that determine the fundamental approach. First, JWSOL must be general in purpose but not ambiguous in structure. There is tension inherent in this position: the less specific the perspective, the more choices exist for classification; the more choices, the greater the risk of arbitrariness. A naturalistic approach was selected as a means to minimize artificiality. The point of using OT is to aid people in managing complexity. Simplicity of mapping from computational objects to the real world is the key to managing complexity. Naturalism is the simplest possible mapping. There is a risk in this approach, however. Although consistent with the current best practices in OT, it is not the only way to classify.

Flexibility and extensibility are also required. Flexibility is inherent in using class templates and inheritance to define instances. The possibilities are limited only by the imagination. Extensibility refers both to extension outward to a greater number of subjects or layers of command, and to extension inward to greater degrees of resolution for the things represented. For outward extension, JWSOL provides a domain representation and a reference point. Inward expansion is doable, but more complex.

Dealing with multiple resolutions is currently one of the most difficult M&S issues. Resolutions range from theater-level model components like JWSOL to ultra-fine-grained models like ARPA's "smart product models," 200-gigabyte acquisition models that incorporate performance, reliability, and even computer-aided design/computer-aided manufacturing (CAD/CAM) information. Not only is there a wide range of resolutions, but there is the related problem of "perspectives"; that is, "outside" model entities may not be authorized and/or have the (simulated) capability to see particular model objects in their ground truth state (i.e., for a particular model, Element A can only see high-resolution Element B at low, or even fuzzy, resolution).

Second, JWSOL is descriptive, not prescriptive. Normal terminology and normal meanings are used for concepts. To the extent that military doctrine provides meanings for terms and references, users will build on those terms when employing JWSOL. The user will not have to learn new terminology or use labels differently in JWSOL than are used in the real world.

The naturalistic approach has wide acceptance. The JTF–ATD C^2 Schema, NSS, and MARS all take this approach. Consequences of this approach include the following:

1. The occurrence of pure abstractions, or metaclasses, are minimized. JWSOL does have “land vehicles,” “vessels,” and “aircraft.” The bias, however, is to actual things. An important caveat is that the military domain is, in general, as equally rich in concepts as it is in things. Some “things” are appropriately conceptual, e.g., a Division Commander may think in terms of Armored Brigades, whereas a Platoon Commander may think in terms of tanks. Because of this, the natural notion triggered by a class name is intended to meaningfully constrain the class content.
2. As with classes, so with relationships. A thing has a location in space and time. It is only from an organizational or planning perspective that it is, for example, part of a “concentration of force.” So that relationship (membership in “concentration of force”) is represented at the organizational level, where it exists in the real world, but not at the tank or artillery piece level.
3. There are no simulation classes or objects in JWSOL. JWSOL does not have an “event queue” object, a “time-step” object, or a “display summary statistics” object. JWSOL is not a model, or even a model construction toolkit. This is a significant difference between JWSOL and (for example) the JTF–ATD C^2 Schema, which will include both domain objects and modeling classes.

The Composite Warfare Model (CWM), a Navy simulation used successfully by the Space and Naval Warfare Systems Command (SPAWAR) and others, uses a fairly radical decomposition in which most attributes and methods are in their own class. Objects may have hundreds of superclasses. Written in Common Lisp, CWM is “linguistically advantaged” for this approach; however, it stands as a counterexample to the naturalistic approach. For multiple users, with differing needs and backgrounds, naturalism is appropriate; however, this is a hypothesis, and in the world of simulation, CWM has been at least as successful as, say, MARS (a more naturalistic object-oriented simulation).

Another related hypothesis is that a general-purpose taxonomy will be useful. This is not as obvious as it seems. Consider underwater detection. From a generalist (and naturalist) point of view, the way to model it would be to have a sensor, a target, and the environment. The sensor would be responsible for its own range and sensitivity, the target for its signature (e.g., noise, wake, emissions, electromagnetic presence), and the environment for its transparency or opacity with respect to the sensor. However, in undersea detection modeling, all three of these distinct classes, sensor, target, and environment, are often grouped together into “detection environment,” and very specific models are produced to model the interactions. If JWSOL’s, and, as has been noted, JTF–ATD C^2 Schema’s and NSS’s hypotheses are that general models’ advantages outweigh the power of specialized models, the challenge is to demonstrate this in fact.

2.2.2 Specific Technical Goals

JWSOL must first support M&S at the theater (joint) level. This will develop “joint” objects that can be easily adapted for reuse by component Services in more limited M&S efforts. The objects will support models and simulations for operations, tactics and doctrine, performance enhancement, and training.

JWSOL must serve as a repository of reliable, robust, reusable warfare simulation classes and objects that can be used to develop and populate a wide range of joint models and scenarios. In object-oriented technology (OOT), the domain decomposition process is highly subjective. This results in serious design differences and incompatibilities that hinder interoperability in the Joint M&S industry. The JWSOL team has used SMEs collectively to identify the objects through an iterative process, thereby fostering compatibility. This approach increases the potential for object reuse, thus minimizing development and maintenance costs. The object library will be designed to support the seamless exchange of information between separate simulations, both within and between the Services.

Despite the extensive cutbacks in funding and personnel across the Services, there is a growing requirement for “jointness” in tactical theater-level planning and exercises. Too often only lip-service has been paid to the term “joint.” Individual Services develop “joint” models that merely address how that Service will perform in a joint environment. Often, as a result, multiple models or simulations are developed to support the same overall functional or joint mission area. These models frequently are incompatible and fail to achieve a true replication of joint functionalities.

2.3 RELATIONSHIP OF JWSOL TO DoD MASTER PLAN FOR MODELING AND SIMULATION

The DMSO Master Plan for “DoD Modeling and Simulation (M&S) Management” implements DoD 5000.59 policy; establishes DoD-wide M&S objectives; provides a comprehensive framework for the planning, programming, and budgeting of M&S projects; and assigns responsibilities for its implementations. The “vision” for M&S described in this plan addresses the following:

> Defense modeling and simulation will provide readily available, operationally valid environments for use by DoD components:
>
> – To train jointly, develop doctrine and tactics, formulate operational plans, and assess warfighting situations,
>
> – To support technology assessment, system upgrade, prototype and full-scale development, and force structuring.
>
> Furthermore, common use of these environments will promote a closer interaction between the operations and acquisition communities in carrying out their respective responsibilities. To allow maximum utility and flexibility, these modeling and simulation environments will be built from affordable, reusable components interoperating through an open systems architecture.

A baseline M&S assessment has identified several shortfalls that must be corrected in order to realize the vision described above. These shortfalls are addressed in six DoD-wide objectives:

1. Establish a common high-level simulation architecture to ensure the appropriate interoperability of live, virtual, and constructive simulations, and their interface with command, control, communications, computers, and intelligence (C^4I) systems.
2. Provide timely and authoritative representations of the natural environment.
3. Provide authoritative representations of systems.
4. Provide authoritative representations of human behavior.
5. Establish an M&S infrastructure to meet developer and end-user needs.
6. Share the benefits of M&S.

JWSOL addresses the first objective above by providing a comprehensive library of objects that can be used in a variety of models and simulations across the Services. In the development of this object library, JWSOL has emphasized the identification of requisite environmental objects (objective 2). JWSOL places a priority on the natural environment, including environmental effects on systems and system effects on the environment. The expertise of SMEs has been used in the identification of system objects (e.g., vehicles, weapons, and command, control, communications, and intelligence (C^3I) systems [objective 3]). This same expertise is identifying objects necessary to support the decision-making process, with emphasis on decision making under stress (objective 4). The library will provide a capability that will simplify the M&S developer's task and meet the end-user's need (objective 5). The standardization of objects will help ensure consistency in simulation results, simplify maintenance, foster code-sharing, and promote interoperability. The reusable and tailorable objects will aid in the interfacing of models and simulations both within and between Services (objective 6).

The DoD M&S Master Plan addresses 10 technical goals for a high-level simulation architecture:

1. Entity-level representation
2. Interoperability
3. Reuse
4. Portability
5. Distributed operation
6. Legacy interface
7. Scalability
8. Broad functional applicability
9. Technological evolvability
10. Commercial off-the-shelf/government off-the-shelf (COTS/GOTS) use

These goals are also objectives of JWSOL.

3. USES AND USERS

JWSOL is a theater-level object library. Unified commands exist to pursue U.S. strategic goals at the political and military levels. Political issues and concerns are beyond the scope of this document, but they underlie much of what the Unified CINC does on a day-to-day basis. Military strategy at the CINC level involves the application of military force to accomplish the mission(s) assigned by the National Command Authority (NCA), the President, and the Secretary of Defense.

Typically, military commanders conceptualize their forces two levels below their own. In the two-tiered Theater Command structure shown in figure 1 (CINC directly to the JTF Commander) used in JWSOL, combat and sustainment capabilities of small tactical level units are aggregated to the level of composite division/separate brigade and their equivalents. Although squads and platoons are not shown, they are represented in the roll-up numbers of equipment and personnel assigned to parent organizations. This section goes into more detail on what analysis areas it is suitable for, how it can be used within those areas, and who can use it. Although this approach appears truncated, it is intended that further refinements of the taxonomy delve deeper into smaller unit levels.

3.1 M&S USE AREAS

JWSOL is being designed with multiple applications in mind.

Operational applications include operational planning, course-of-action (COA) development and evaluation, and reconstruction of operations to facilitate lessons-learned studies. These can be either real-time or deliberate. JWSOL will provide a strong set of validated base class definitions and objects for these activities.

Decision support includes threat modeling, “what-if” analyses, planning support in all military functional areas, automated critiquing, wargaming, and expert systems. A future release of JWSOL will provide explicit, fully integrated user-modifiable knowledge representation (with change authorization control), along with limited support for platform-independent multimedia presentation, including integration of knowledge representation and reasoning with textual, graphical, video, sound, mapping, and data visualization. A variety of government off-the-shelf (GOTS) tools exists for knowledge representation and reasoning (e.g., CLIPS, KRSL). With respect to multi- and hypermedia, the JTF–ATD exploration of web-based blackboards is extremely interesting.

Logistics includes detailed planning and execution monitoring in mobilization, transportation, sustainment, consumption forecasting, and dealing with temporal dependencies and constraints. As above, a robust set of validated class definitions and objects supports logistics analysis.

Training has special needs. The domain of joint training is just now evolving into a discrete military function. In anticipation of emerging needs to support joint training, the Universal Joint Task List (UJTL), published by J-7 of the Joint Staff, has been used as a fundamental document. The UJTL is a superb source of theater-strategic-level tasks, conditions, and standards that must be accomplished by theater CINCs and their staffs. For training, these tasks must therefore be “modelable,” using objects in JWSOL. Trainers may need to loosen otherwise firm constraints in order to exercise at boundary conditions and to concurrently manage both ground truth and perceived situations for multiple threats or users. JWSOL currently supports only ground truth. However, the notion of “perspectives,” discussed in section 6, is a natural and seamless extension of JWSOL’s current taxonomic structure. Perspectives would support perceived situations while preserving an explicit

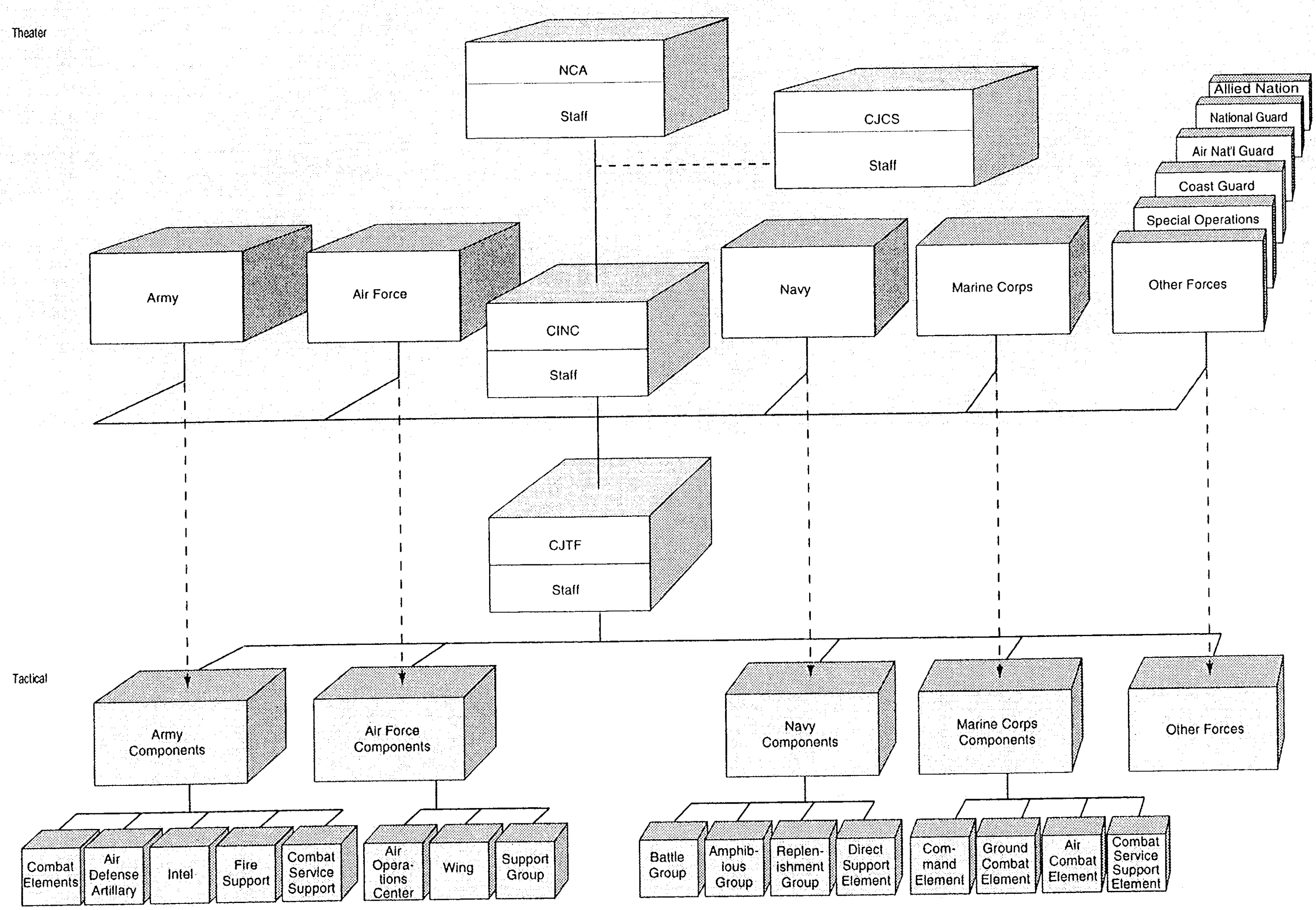

Figure 1. Representation of a two-tiered theater command and control organization, showing the more widely used Service (vice functional) components. The solid lines show operational control. The dotted lines show administrative relationships. The lower shaded area shows the depth to which CINC would look—which is the depth to which JWSOL goes in its taxonomic representation.

separation of ground truth from perception. JWSOL will also be suitable for support of exercises and synthetic environments should it be incorporated into a Model Request Broker (discussed briefly below and in more detail in section 6.2) or used directly as a standard or part of a standard for model interoperation.

Acquisition is a significant area of military modeling. An interesting development in acquisition is the increasing emphasis on independent validation of mission effectiveness improvement for proposed acquisitions. In the past, the same agencies and program offices that were promoting a particular acquisition would also build models to measure the positive consequences of making the very acquisition they were advocating. Recently, there has been increased awareness that independent validation is necessary. This is part of the impetus for the unified High-Level Architecture. JWSOL has the potential to be a neutral provider of domain objects against which a potential acquisition can be tested.

3.2 CLASSES OF USE

The JWSOL object taxonomy can be used to develop new models and simulations and as a medium for interoperation between independently developed M&S systems.

Development of new models using JWSOL objects is simplified. There are three parts to construction of a new model or simulation: modeling the subject domain, providing the computational infrastructure, and developing the user environment and its scenario generation and postanalysis tools. It is generally considered that the first of these is the most important; JWSOL facilitates this activity.

JWSOL supports interoperability on three levels.

Directly. Models that use JWSOL objects will have a direct, object-to-object correspondence. Interoperation can then either be within a workspace, or across workspaces, mediated by operating system or distribution operating systems calls, or via CORBA.

Indirectly. JWSOL class definitions will provide an interface template that could be used to generate container objects for either DIS-compliant or non-DIS models and simulations. Any simulation using JWSOL class definitions or objects in its external interface would then be able to take advantage of the direct style of interoperation described in the preceding paragraph.

Via a Model Request Broker. A Model Request Broker (MRB), analogous to an Object Request Broker but on a higher level of abstraction, could, if implemented, provide a standardized interface for model interaction. The Interface Definition Language (IDL) equivalent for an MRB should be a set of standard templates of entity and nonentity level interactions. JWSOL class definitions are exactly such a set of templates. JWSOL is a leading candidate for incorporation in an MRB, should the project that proposed the idea, the Navy Simulation System (NSS), continue into MRB development.

3.3 LEVELS OF USE

JWSOL will be used at four levels: the user/analyst, the content modeler, the perspectives modeler, and the programmer. At the user/analyst level, class definitions and objects will be used (in the context of particular simulation environments) to assemble models and model components for simulation. This level of use is appropriate for both program and warfare analysts, and for decision-makers. Content modelers will be able to edit values and attributes of specific warfare and environmental classes, and will be able to combine classes in novel ways to test the effects of such combinations.

In a future version of JWSOL, perspective-modelers, primarily trainers, will be able to explicitly control the perspectives available to users and, through both attribute value assignment and knowledge representation, the situations their trainees will encounter. Finally, programmers will have access to industry-standard object-oriented analysis and design materials, professional-quality documentation, and implemented objects.

3.4 COEVOLUTION WITH OTHER PROGRAMS

As indicated above (section 1.2), JWSOL is a contribution to a broad M&S community "discussion" of taxonomic and domain representation issues. JWSOL has significantly interacted with two programs: NSS and JTF–ATD Object Modeling Working Group (OMWG).

NSS is a multiyear project to develop a single, unified, Navy-wide architecture for modeling and simulation. NSS is innovative in several respects:

- NSS emphasizes fielding operational software. The first release of NSS will be installed at Commander in Chief, U.S. Pacific Fleet (CINCPACFLT) by August 1995. Subsequent major releases are scheduled at 12-month intervals.
- NSS programmatically unifies a number of distinct Navy and Marine laboratories and commands into a cooperative, collaborative development team.
- NSS incorporates distributed, lab-authority-centered verification, validation, and accreditation (VV&A) from the beginning.
- NSS is participating in the DMSO effort to define a DoD-wide generic High-Level Architecture described in the DoD Master Plan for Modeling and Simulation (discussed in section 2.3).

NSS Release 1 has already incorporated JWSOL preliminary taxonomic elements. It is anticipated that Release 2 will further use maturing JWSOL classes. JWSOL technical staff are closely following the ongoing development of NSS, so that any changes the NSS team feels are needed to be effective for their domain can be assimilated (as appropriate) into JWSOL. A productive dialog exists and continues to be nurtured, with each party benefiting from the work of the other.

The JTF–ATD OMWG is supporting the large JTF–ATD activity by defining the Command and Control (C^2) Schema, considered by the technical directors of the various subactivities to be the "glue" that will hold the entire project together. Not only have JWSOL team members been active in the OMWG, but many JWSOL classes and class relationship structures have been directly adopted by the OMWG as well as by the Data Server group within the JTF–ATD.

So this is not misconstrued, knowledge and insight have flowed from the OMWG and the Data Server to JWSOL as much as vice versa. The OMWG has provided both breadth and depth of knowledge in several areas, resulting in significant improvements to the JWSOL taxonomy presented here. In the wide area of shared perspective, similar enough structures evolved independently that little effort was required to join them into a single representation. The relationship between JWSOL and the JTF–ATD OMWG and Data Server has been productive.

However, JWSOL, the JTF–ATD C^2 Schema, and the JTF–ATD Data Server each have different requirements and constraints. In the wide area where there is a strong overlap, it is hoped that the productive mutual support seen thus far will continue and thrive. JTF–ATD program manager Dr. John Schill has described the JTF–ATD design as a "maximum-theft architecture"—meaning that he hoped as much of the JTF–ATD design and development work as could be broadly used would be broadly used. JWSOL is in complete agreement, with no restrictions on the direction of influence.

4. PROGRAM CONTEXT

This section reviews the genesis and status of JWSOL and acknowledges two related programs that have been of value and have influenced the JWSOL program.

4.1 HISTORY AND STATUS OF JWSOL

In December 1992, the Naval Command, Control and Ocean Surveillance Center RDT&E Division (NRaD) submitted a proposal in response to DMSO's FY 93 Focused Call for Projects. The proposed effort was to produce a set of software "objects" for use in object-oriented simulation of warfare. DMSO recognized the need for Joint Service research of the application of object technology (OT) design to the domain of warfare and, in August 1993, the 3-year, three-phase JWSOL program was initiated with DMSO funding. The JWSOL approach addresses the goals and objectives as defined in the DMSO Master Plan and as stated in section 2.3.

The first phase of the program has resulted in a comprehensive joint warfare requirements definition [5] and the decomposition of the warfare process into objects, as represented in this taxonomy document. This work was accomplished by a Joint Service C^2 laboratory team. Warfare analysts, representing each Service, participated in identifying and specifying each Service's joint simulation requirements in collaboration with an OT design expert and NRaD personnel. This effort resulted in a comprehensive taxonomy, or OT hierarchical design of joint warfare simulation requirements, which is a necessary first step toward having DoD simulation projects that will interoperate with other simulations. The requirements and preliminary taxonomy were validated against Joint Chiefs of Staff (JCS) policy, and comments from a comprehensive review were incorporated.

The second phase, development of the object specifications for the warfare objects, is being initiated. These specifications are being documented in an object model using Rumbaugh notation. The construction of the object specifications during this second phase of the JWSOL effort will be an iterative process of prototyping and documenting. Iterations will continue until the entire set of objects, with their related inheritance hierarchies and "part of" hierarchies, merges in a final design. The third phase consists of fielding, filling, verifying, and validating, as well a maintaining, the JWSO Library.

4.2 RELATED PROGRAMS: JSIMS AND JWID 95

The Joint Simulation System (JSIMS) is a joint effort being supported by the military Services to provide more disciplined development, better focus, and significant M&S investment economies of scale while increasing both the reliability and the credibility of component Service M&S tools. Historically, the Services have independently developed training models and simulations. This has resulted in duplication, interface problems, data-sharing difficulties, and inefficient investment of critical dollars. JSIMS will include missions across the full range of military operations. The system will address the complete joint and multinational operational environment. JSIMS is being designed to support those tasks addressed in the UJTL published by the Joint Staff.

The JWSOL effort is attempting to be responsive to JSIMS needs, so valuable review of JWSOL documentation and comments on JWSOL SME taxonomic recommendations have been provided by JSIMS personnel. The JSIMS primary operational goal of using object-oriented design techniques for reusability, portability, and interoperability of object-based software components in distributed environments is supported by JWSOL objectives. Also, to ensure joint interoperability of products, both the UJTL and JSIMS were used as sources of JWSOL functional requirements.

Planning is well underway for Joint Warrior Interoperability Demonstration (JWID) 95. Scheduled for the last two weeks in September 1995, JWID 95 will focus on Disaster Relief and Humanitarian Assistance. A wide variety of participants representing the various Services will demonstrate the applicability of a multitude of technologies in this collaborative planning exercise. This JWID will build on the lessons learned from JWID 94. JCS priorities for JWID 95 include focusing on the warfighter and basing the scenario on current events, including a Hurricane Andrew-type storm to generate a domestic disaster relief effort in Hawaii.

The JWSOL taxonomy and objects will be provided to the JWID planners to support the interoperability of simulations. In concert with the JTF–ATD C^2 Schema, this will help minimize development costs while promoting the seamless exchange of objects between simulations of multiple Services.

5. REQUIREMENTS

5.1 JWSOL REQUIREMENTS DOCUMENT

The JWSOL taxonomy is the product of extensive requirements analysis, recorded in the JWSOL Requirements Definition [5]. The warfare domains of each Service are so extensive that a boundary needed to be defined in order to focus on objectives that could be realized and demonstrated in a relatively short period of time. The theater tactical level of warfare was selected. Specifically, requirements were specified to support the command decision-making process at that level.

Subject matter experts representing the Services used the *Joint Staff's Unified Joint Task List (UJTL)* [13], AFSC Pub 1—*The Joint Staff Officer's Guide 1993* [1], and the Training and Doctrine Command's (TRADOC's) Pamphlet No. 11-9—*Blueprint of the Battlefield* [12]. as a foundation for the requirements definition. The requirements identified for JWSOL were divided into six sections: general, Joint, Army, Navy, Marine, and Air Force requirements.

The JWSOL Requirements Definition document specifies what must be done, not how the work is to be done. The development of the requirements document was a necessary precursor to the design or implementation phase. It provided important information that has minimized risk and aided in the efficient expenditure of resources. The identified requirements were used to produce the warfare objects specified in this taxonomy.

5.2 MISSIONS AND THEIR IMPLICATIONS

The JWSOL taxonomy was defined from the missions the CINC may need to accomplish. Mission diagrams, shown in figures 2 through 5:

- Map the joint mission area to the JWSOL Requirements,
- Show the Service(s) involved in the mission area,
- Identify the taxonomic command headquarters,
- Identify the unit(s) taking the action(s),
- Show the class(es) of object accomplishing the action, thus completing a "mission thread" from joint command level through and including the major equipment object, which is used to fulfill the mission.

Two additional diagrams, figures 6 and 7, are functional representations of the intelligence and sustainment processes. These are critical supporting mission areas that must be represented for planning at the theater level. They are included in the JWSOL approach along with operations because of their importance and their representation in the UJTL.

5.3 VERIFICATION AND VALIDATION (V&V)

Verification refers to software systems. A verified system fulfills its specification and operates without fault. Validation applies both to software and to the content of models and simulations. Validation means that the content is correct with respect to the problem to be solved or the material to be represented. Authentication, an additional qualifier, refers only to models, and means that authorized SMEs affirm that, within a specified context and level of resolution, and with respect to a specified use, the model truly reflects reality. JWSOL is not intended to result in the delivery of a working model. Therefore, verification does not apply to this effort.

JWSOL Requirements Definition Para	Mission Area		Service	Command Headquarters	Command Element	Action Unit	End Item
	Air Missions						
4.2.4d	Offensive Air (OAS) (CAS)	yes	USAF	# Air Force	Air Wing	Sqdn	F-15, F-16
		yes	USMC	MEF(F)	MAG	Sqdn	F/A-18, AV-8, A-6
		yes	USN	# Fleet	CAW	Sqdn	F/A-18, A-6, F-14
		no	USA				
4.2.4a	Air Interdiction (AI)	yes	USAF	# Air Force	Air Wing	Sqdn	F-15, F-117, F-16, B-52, B-1, B-2
		yes	USMC	MEF(F)	MAG	Sqdn	F/A-18, AV-8, A-6
		yes	USN	# Fleet	CAW	Ssqdn	F/A-18, A-6, F-14
		no	USA				
4.2.5a(1)	Defensive Air (DAS)	yes	USAF	# Air Force	Air Wing	Sqdn	F-16, F-15
		yes	USMC	MEF(F)	MACG	Bn	Hawk, Stinger
					MAG	Sqdn	F/A-18
		yes	USN	# Fleet	AAWCdr	Ship	Tartar, Terrier
					CAW	Sqdn	F-14, F/A-18
		yes	USA	Corps	Division	Bde	Patriot, Hawk, Stinger
	Special						
4.2.4c	- ECM	yes	USAF	# Air Force	Air Wing	Sqdn	EC-130, F-15
		yes	USMC	MEF(F)	MAG	Sqdn	EA-6B, F/A-18(Pod)
		yes	USN	# Fleet	CAW	Sqdn	EA-6B, F/A-18(Pod)
		yes	USA	Corps	Division	Bde	Guardrail, EH-60
4.2.5a(4) 4.2.2h	- ESM	yes	USAF	# Air Force	Air Wing	Sqdn	EC-130, JSTARS
		yes	USMC	MEF(F)	MAG	Sqdn	EA-6B, F/A-18(Pod)
		yes	USN	# Fleet	CAW	Sqdn	EA-6B, F/A-18(Pod)
		yes	USA	Corps	Division	Bde	Guardrail, Quickfix
4.2.7e	- Intratheater MED EVAC	yes	USAF	# Air Force	Air Wing	Sqdn	HS-3, H-3, CH-3, MH-53, UH-60
		yes	USMC	MEF(F)	MAG	Sqdn	UH-1, CH-46, CH-53
		yes	USN	# Fleet	CAW	Sqdn	SH-60
		yes	USA	Corps	Division	Sqdn	UH-1, UH-60, H-47
4.2.7e	- Intertheater MED EVAC	yes	USAF	# Air Force/AMC	Air Wing/MEDCOM	Sqdn	C-9, C-21, C-26, C-141
		no	USMC				
		no	USN				
		no	USA				

Figure 2. Air missions.

JWSOL Requirements Definition Para	Mission Area		Service	Command Headquarters	Command Element	Action Unit	End Item
	Air Missions (continued)						
	Special (continued)						
4.2.5b	- Air Rescue	yes	USAF	# Air Force	Air Wing	Sqdn	HS-3, H-3, CH-3, MH-53, UH-60
		yes	USMC	MEF(F)	MAG	Sqdn	UH-1, CH-46, CH-53
		yes	USN	# Fleet	CAW	Sqdn	SH-60
		yes	USA	Corps	Division	Sqdn	UH-1, UH-60, H-47
		yes	USCG	CG District	Air Station	Sqdn	Various
4.2.4d	- ASW	no	USAF				
		no	USMC				
		yes	USN	# Fleet	ASW Cdr	Ship/Sub Sqdn	Depth Bomb, Torpedo S-3, SH-2, SH-60, P-3
		no	USA				
4.2.2	- C2	yes	USAF	# Air Force	Air Wing	Sqdn	AWACS, ABCCC, E-3A
		yes	USMC	MEF(F)	MAG	Sqdn	UH-1, F/A-18
		yes	USN	# Fleet	CAW	Sqdn	E-2C
		no	USA				
4.2.6a	- Reconnaissance	yes	USAF	# Air Force	Air Wing	Sqdn	U-2
		yes	USMC	MEF(F)	MAG	Sqdn	F/A-18 (pod) RPV
		yes	USN	# Fleet	CAW	Sqdn	RF-4B, F-14 (TARPS)
		yes	USA	Corps	Avn Bde	Sqdn	0-10D
4.2.7e	- Refueling	yes	USAF	# Air Force	Air Wing	Sqdn	KC-10, KC-135
		yes	USMC	MEF(F)	MAG	Sqdn	KC-130
		yes	USN	CAW	CAW	Sqdn	KA-6, S-3
		no	USA				
4.2.7b	- Intratheater Airlift	yes	USAF	# Air Force	Air Wing	Sqdn	C-130, C-141, C-9
		yes	USMC	MEF(F)	MAG/Air Station	Sqdn	CH-46, CH-53, C-9, C-12, KC-130
		yes	USN	# Fleet	CAW/Air Station	Sqdn	CH-46, SH-60, H-1, C-2, C-9, C-12
		yes	USA	Corps	Division	Avn Bde	CH-47, UH-60, UH-1, C-12
		yes	ANG	Governor / # Air Force	Air Wing	Sqdn	C-130, C-141
		yes	Allied/Host Nation	Ambassador	Country Team	Units	Various

Figure 2. Air missions (continued).

JWSOL Requirements Definition Para	Mission Area		Service	Command Headquarters	Command Element	Action Unit	End Item
	Air Missions (continued)						
	Special (continued)						
4.2.7b	- Intertheater Airlift	yes	USAF	US TRANSCOM	Air Wing	Sqdn	CRAF, C-5, C-17, C-141
		yes	USMC	US TRANSCOM	Air Station	Sqdn	C-9
		yes	USN	US TRANSCOM	Res AW/PATWING	Sqdn	C-9, P-3
		yes	USA	US TRANSCOM	MTMC	Various	Various
		yes	ANG	US TRANSCOM (Coord)	Air Wing	Sqdn	C-5, C-141
		yes	Allied/Host Nation	US TRANSCOM (Coord)	Country Team	Units	Various

Figure 2. Air missions (continued).

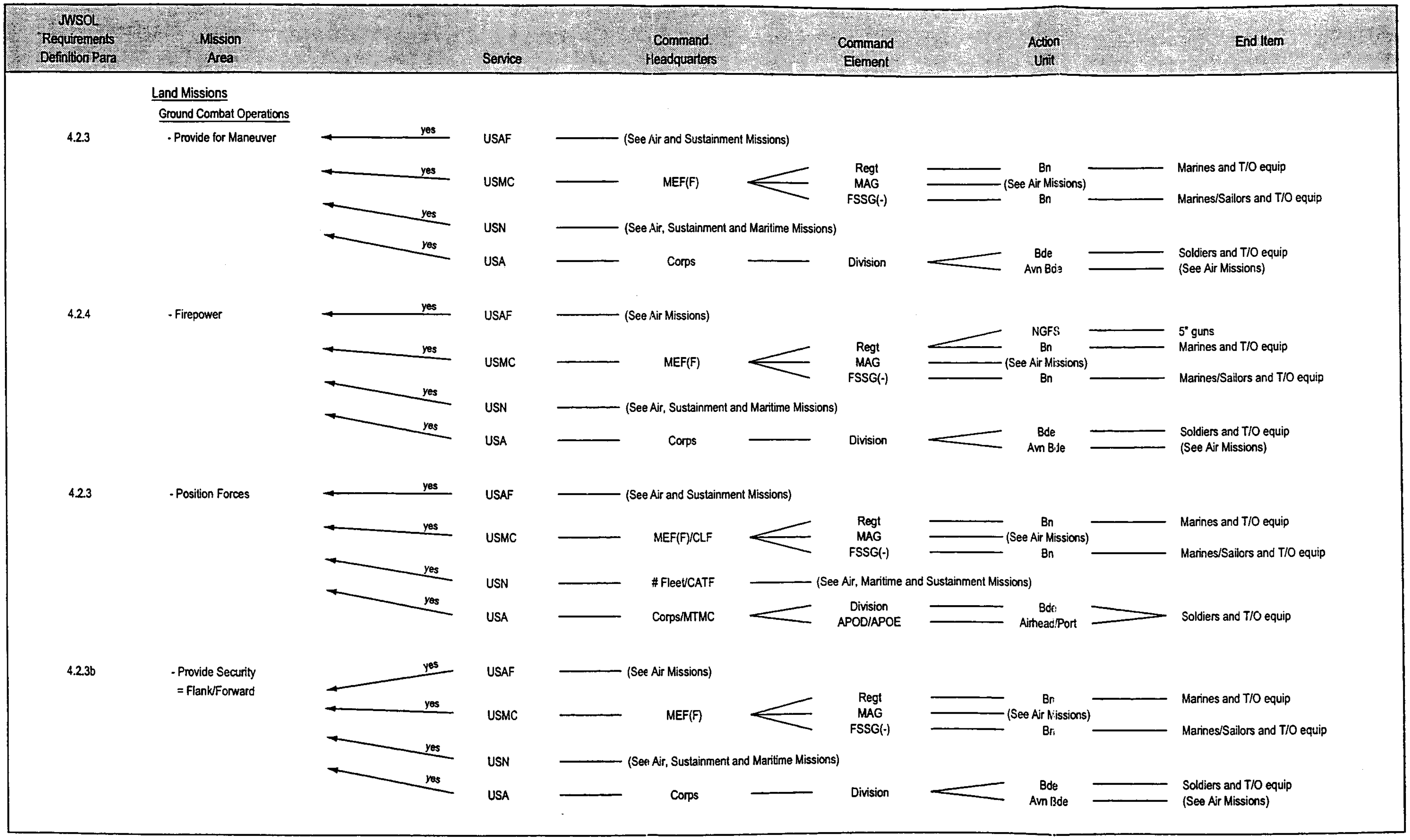

Figure 3. Land missions.

JWSOL Requirements Definition Para	Mission Area		Service	Command Headquarters	Command Element	Action Unit	End Item
	Land Missions (continued)						
	Ground Combat Operations (continued)						
4.2.5b	- Provide Security (continued)	yes	USAF	# Air Force	Air Wing/Air Base	Sqdn	Organic and attached people and equip
	= Rear Area	yes	USMC	MEF(F)	FSSG(-)	Bn	Marines/Sailors and T/O equip
		yes	USN	(See Air, Sustainment and Maritime Missions)			
		yes	USA	Corps	Division/RAOC	ADA Units/ Maneuver Units	Soldiers and T/O equip
		yes	Allied/Host Nation	Ambassador	Country Team	Units	People/equip as assigned

Figure 3. Land missions (continued).

JWSOL Requirements Definition Para	Mission Area		Service	Command Headquarters	Command Element	Action Unit	End Item
	Sea and Maritime Missions						
	Power Projection						
4.2.[illegible]	- Amphibious Assault/ Withdrawal	yes	USAF	(See Air Missions)			
		yes	USMC	Landing Force	Regt	Bn	Marines and T/O equip
					MAG	(See Air Missions)	
					FSSG(-)	Bn	Marines/Sailors and T/O equip
		yes	USN	Amphib Task Force	Amphib Sqdn	Ship	Landing Craft
		yes	USA	Landing Force	Division	Bde	Soldiers and T/O equip
4.2.4d	- Maritime Prepositioning Force	yes	USAF	(See Air Missions)			
		yes	USMC	MEF(F)	Regt	Bn	Marines and T/O equip
					MAG	(See Air Missions)	
					FSSG(-)	Bn	Marines/Sailors and T/O equip
		yes	USN	# Fleet	CMPF	prep ships Sqdn	Soldiers and T/O equip
		no	USA				

Figure 4. Sea and maritime missions.

JWSOL Requirements Definition Para	Mission Area		Service	Command Headquarters	Command Element	Action Unit	End Item
	Sea and Maritime Missions (continued)						
	Battle Space Domination						
4.2.5b	- SLOC Protection	yes	USAF	# Air Force	Division	Sqdn	F-117, B-52, B-1
		yes	USMC	Landing Force	Division	Sqdn	AV-8, F/A-18, A-6
		yes	USN	# Fleet	PATWING	Sqdn	P-3
					CAW	Sqdn	A-6, F/A-18, F-14, E-2
					Sqdn	Ship/Boat	S/A missiles, Tomahawk, torpedoes
		no	USA				
4.2.5b	- Mine Warfare	yes	USAF	# Air Force	Air Wing	Sqdn	B-52 (mines)
		yes	USMC	MEF(F)	MAG	Sqdn	A-6 (mines)
		yes	USN	# Fleet	CAW	Sqdn	A-6 (mines)
					Sqdn	Ship	mines
		no	USA				
4.2.5b	- Countermine Warfare	no	USAF				
		no	USMC				
		yes	USN	# Fleet	CAW	Sqdn	CH-53
					Sqdn	Ship	MSO
		no	USA				
4.2.3b	- Amphibious Raid	yes	USAF	# Air Force	Air Wing	Sqdn	B-52, F-117, B-1
		yes	USMC	Landing Force	Regt	Bn	Marines and T/O equip
					MAG	Sqdn	CH-46, CH-53, UH-1, F/A-18
					FSSG(-)	Bn	Marines/Sailors and T/O equip
		yes	USN	Amphib Force	Amphib Sqdn	Ship	Sailors and T/O equip
		yes	USA	Landing Force	Division	Bde	Soldiers and T/O equip

Figure 4. Sea and maritime missions (continued).

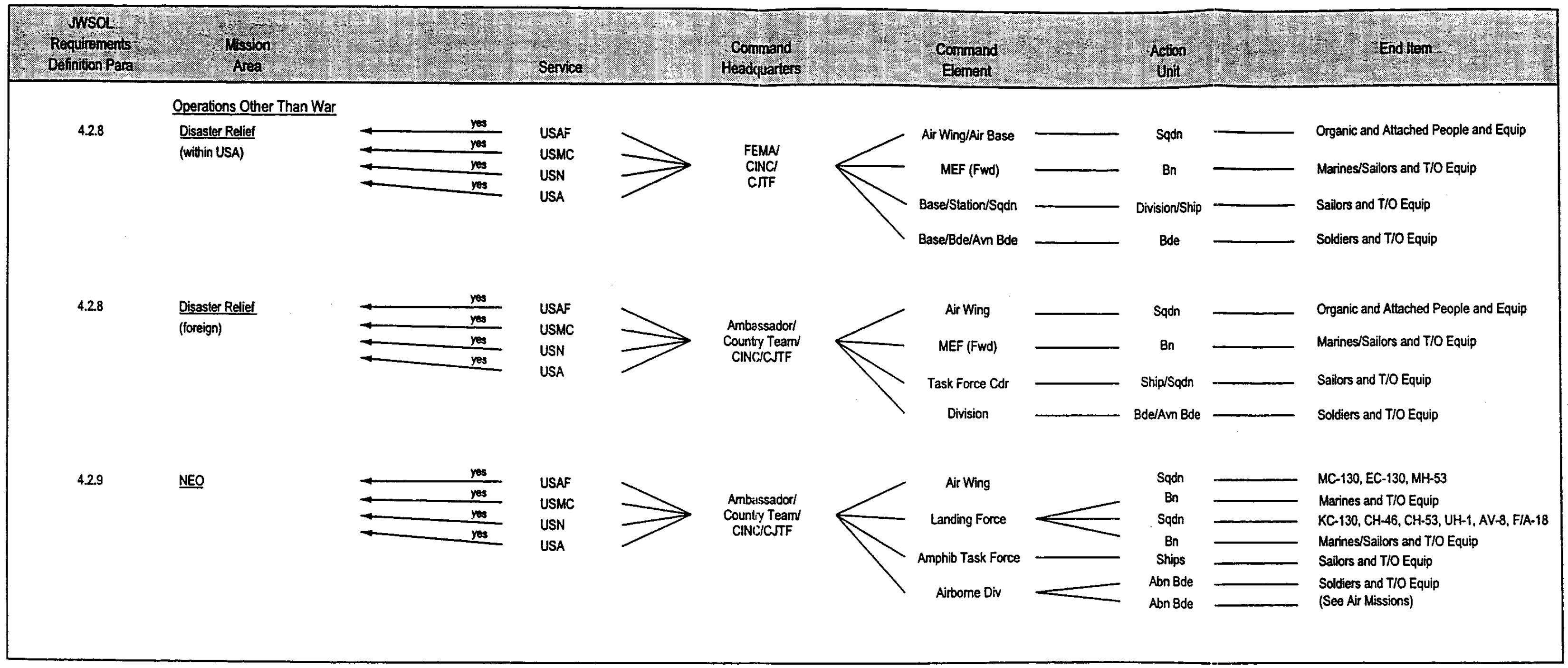

Figure 5. Operations other than war.

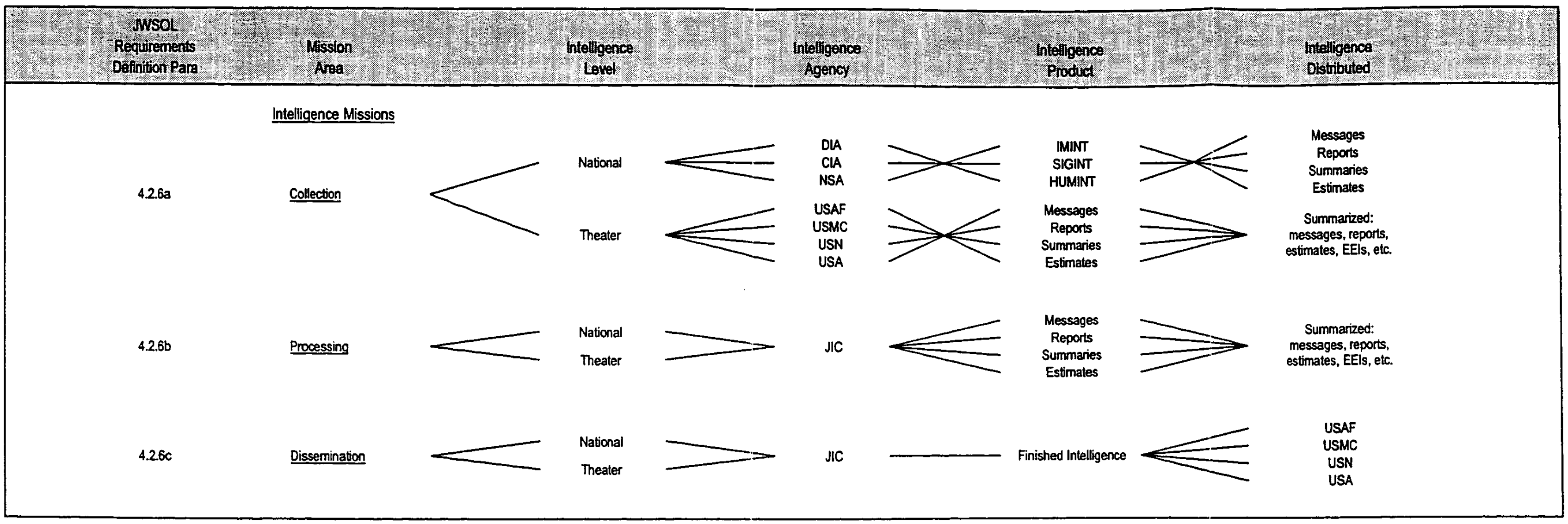

Figure 6. Intelligence missions.

JWSOL Requirements Definition Para	Mission Area	Service	Supply	Equipment	Personnel	Required DOS	Consumption Rate	Critical Item
4.2.7	Sustainment Missions							
4.2.7a	Forecast Expenditures (CINC Guidance)	USAF	yes	yes	yes	yes	yes	List
		USMC	yes	yes	yes	yes	yes	List
		USN	yes	yes	yes	yes	yes	List
		USA	yes	yes	yes	yes	yes	List
		HN	yes	yes	no	no	no	Request
4.2.7b	Assemble Sustainment Power	USAF	yes	yes	yes	yes	yes	List
		USMC	yes	yes	yes	yes	yes	List
		USN	yes	yes	yes	yes	yes	List
		USA	yes	yes	yes	yes	yes	List
		HN	yes	yes	no	no	no	Request
4.2.7c	Assemble Sustainment Facilities/Units	USAF	yes	yes	yes	yes	yes	List
		USMC	yes	yes	yes	yes	yes	List
		USN	yes	yes	yes	yes	yes	List
		USA	yes	yes	yes	yes	yes	List
		HN	yes	yes	no	no	no	Request

Figure 7. Sustainment missions.

Validation is the only element of V&V that currently applies to JWSOL. The normal best practice for domain content validation is to offer the representation to the scrutiny of SMEs, solicit their comments, and incorporate their corrections. This necessary subject matter expertise has been incorporated in the composition of the task team—Army, Navy, Marine, Air Force, and environment SMEs form the core. In addition, requirements have been submitted, and this document will be submitted to a wide range of SMEs for examination and critique.

5.4 RELEVANT STANDARDS

Two classes of relevant standards pertain to the JWSOL effort: software environment and interoperation.

JWSOL is neutral with respect to software environment and programming tools. If JWSOL is implemented, then specific choices of platform, language, and configuration management tools will have to be made. To enable and encourage reuse, it is anticipated that the analysis and design would be maintained at a level above the implementation.

There are two relevant standards at the model interoperation level: DIS and CORBA. DIS is a body of protocols for real-time interoperation of legacy simulations at the entity level. DIS, running over the Defense Simulation Internet (DSI), has been highly successful, and has been the enabling technology for sophisticated synthetic environments and both live and virtual simulations.

CORBA is now in Release 2.0. CORBA is the key enabling technology for distributed objects. CORBA allows a C^{++} object, running on a Sun workstation, to send and receive messages from a Common Lisp object, running on a Power Macintosh. Also using CORBA, the Common Lisp object can, in turn, receive and send messages to a SmallTalk object running on an IBM Power2 server. CORBA is the product of extended negotiations among major software development houses and research organizations (both private and government). It is a mature standard for object interoperation across software and hardware platforms and languages.

JWSOL, as a source for stand-alone model development, is independent of both DIS and CORBA. Both are appropriate for interoperable JWSOL models. Both can safely be deferred to the implementation phase.

5.5 PROJECTED REQUIREMENTS

Both ARPA and DMSO are pursuing a unified high-level architecture for all military simulation. Multiple ARPA-funded efforts, the NSS, the JTF–ATD, Argonne National Laboratory's Dynamic Environmental Effects Model (DEEM), and several others are participating in developing this architecture. JWSOL also addresses the needs of these projected high-level architectures. Since most of the candidates follow current best practice in object-oriented operating systems development, it is possible to project a generic version of what might emerge from the current effort. Figure 8 shows a generic version of how a unified high-level architecture is likely to appear.

JWSOL resides in three places within the architecture, all in the server layer. First, by its inherent design it can comprise a portion of the Object Repository. Second, it is an integral part of the Model Request Broker (described in section 6.2). Third, it is potentially part of a "front-end" to the Data Server. At the analysis and design levels, no changes are necessary to the JWSOL to satisfy all three of these server requirements.

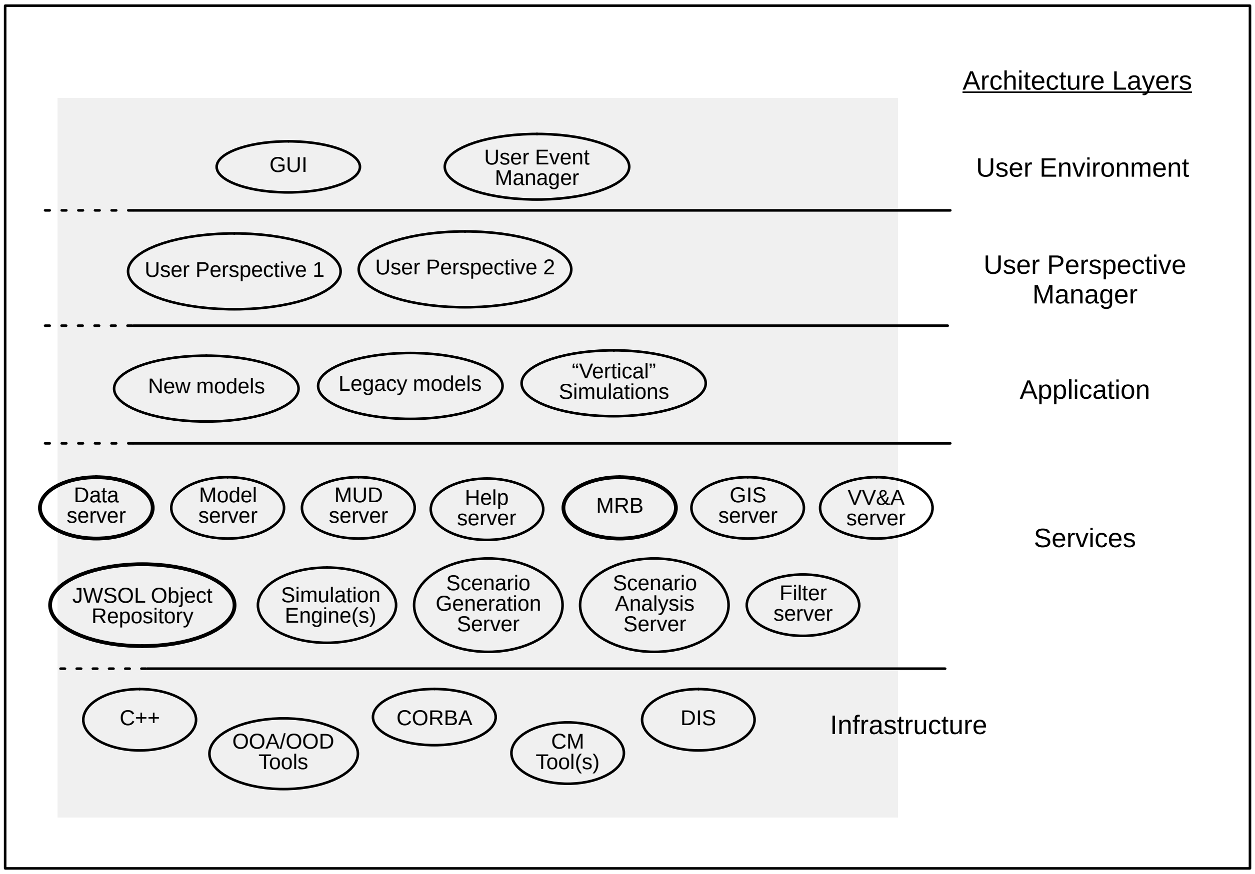

Figure 8. Analgram of elements expected to be present in the DoD Unified High-Level Architecture. JWSOL could contribute to the Object Repository, the Data Server, and the Model Request Broker. This illustration borrows heavily from the layered architecture of the JTF–ATD.

6. TECHNOLOGY

This section:

- Discusses the advantages of object technology (OT),
- Very briefly presents its defining features,
- Introduces the notation used,
- Discusses model interoperation and the role of JWSOL in supporting it,
- Explains some of the problems of classification that make creating an object-oriented taxonomy fundamentally difficult.

6.1 OBJECT TECHNOLOGY

Object-oriented analysis, design, and programming (collectively OT) rest on five pillars: abstraction, hierarchy, inheritance, encapsulation, and polymorphism.

Abstraction is the separation and articulation of those elements or aspects crucial to the identity of a thing from those that can be ignored, at a particular level of discourse. OT expresses abstraction in three ways: with hierarchy, inheritance, and encapsulation.

Hierarchy is the arrangement of parts into a whole, with some form of ordering from top to bottom. OT uses two kinds of hierarchy, generalization/specialization and whole/part. These are sometimes called taxonomic and partonomic. In the generalization/specialization hierarchy, the basic relation is "is-a"; an element lower in the hierarchy "is an" instance of one higher in the hierarchy. For example, a fighter is an aircraft; a tank is a vehicle; an officer is a person. Note that "is-a" applies both to class specialization (a fighter is an aircraft) and to generic/individual mapping (Frig is a Frigate). In the whole/part hierarchy, both composition (is-made-up-of) and association (is-a-member-of) are represented.

Inheritance provides elision. Elements common to several different program elements can be defined once, in one place, at the right level of abstraction, and reused at successively finer degrees of resolution. Inheritance can increase the comprehensibility of complex programs by isolating characteristics and behavior at levels appropriate to the subject matter and at levels of abstraction relevant to the programmers and users of the individual system. Inheritance works only from the more general parent class downward to the more specialized child classes.

Inheritance applies to both attributes and methods. Attribute values can be overwritten or specialized as one moves deeper into a class structure; so can methods. For example, some object-oriented languages provide "before" and "after" method types. When a message is received, triggering the specialized method, the before method is invoked, then the inherited method, then the after method.

Encapsulation is the combination of data and procedures into a whole, with a well-defined and rigorously enforced interface. Encapsulation promotes modularity and independence from particular implementations. With encapsulation, the interior of an encapsulated object can be completely rewritten, and as long as the interactions promised by the interface remain intact, no change is required of the surrounding objects.

Finally, *polymorphism* ("many-formed-ness") provides dynamic binding and multiple receipt for object communications. This means it is not a sending object's obligation to know either exactly to whom it is sending, nor exactly how its message will be processed. This powerfully supports object independence, both conceptually and in terms of implementations and run-time instantiations.

6.1.1 OT Advantages

OT offers significant advantages for defense modeling and simulation as well as decision support and situation development applications. OT simulation of warfare requires decomposing the warfare domain into objects, in contrast to traditional analysis of warfare domain models as processes. Using abstraction permits the OT analyst to focus on what an object is and does, before (and independent of) any implementation decisions. This permits the same objects, and models composed of them, to be used for subject matter analysis, high-level software design, program structure, database structure, and documentation, while deferring programming details until the final stage of development. It is also this aspect of OT that makes a powerful automation tool in other than M&S implementations.

OT also permits the development of flexible and modular objects. For example, if an application needed to have DIS compatibility, inheritance could be used without changing the core object (e.g., a tank is a tank in the object model, but can be a DIS tank in a simulation with no change because it can inherit that capability from the DIS class object). That same tank object could become an Inter-vehicle Information System (IVIS) object for use in C^2 or sustainment applications.

As a DoD modeling and simulation methodology, OT provides an opportunity to build more compatible and interoperable software applications. Access to a sound set of base warfare objects means considerably less work will be required to build applications. This supports the application of such techniques as Rapid Application Development (RAD) and means that project teams can be smaller. When these two factors are considered together (object reuse and smaller project teams), very large gains in productivity are possible.

6.1.2 OT Methodologies and Notation

Several methodologies are being used within the OT community, including Rumbaugh, Booch, Wirfs-Brock, Martin/Odell, Coad/Yourdon, Shlaer/Mellor, and Jacobson. While there are differences among the methods, Rumbaugh's comment that they are all much more similar to one another than any are to traditional approaches seems to reflect a consensus within the OT community.

A modified Rumbaugh approach was chosen because of its expressive power and clarity. Figures 9 through 14 are derived from Rumbaugh. This modified notation is introduced here to make the taxonomic diagrams given in appendix A understandable.

Throughout this section, “class” is used to denote the structural and algorithmic representation of a concept or thing. “Object” is used only to refer to an instance, actually instantiated on a computer, of a class. For example, “F-16E” would have the attributes and methods needed to define an F-16. “F-16E_AF1234A” could then be a particular instance of an F-16E instantiated within a running simulation. The former, F-16E, would be a class; the latter, F-16E_AF1234A, would be an object.

Rumbaugh et al. advocates the notation shown in figures 9 through 14. Class (figure 9) has three parts. The top is reserved for the class name. The middle lists attributes. These are named in the JWSOL taxonomy; in some cases, additional information is specified, e.g., data type, range, legal values, etc. The bottom section lists methods (called “virtual functions” in C^{++}).

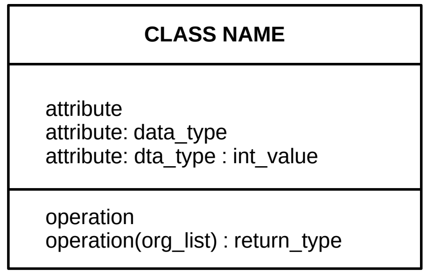

Figure 9. Classes have names, attributes, and methods.

Inheritance is shown by a triangle (figure 10). Conventionally, inheritance is shown with the more general class toward the top of the diagram and the more specialized class(es) toward the bottom. Alternately, the generalization may be toward the left and the specializations toward the right. Multiple inheritance is shown by connecting two or more general classes with a specialization class.

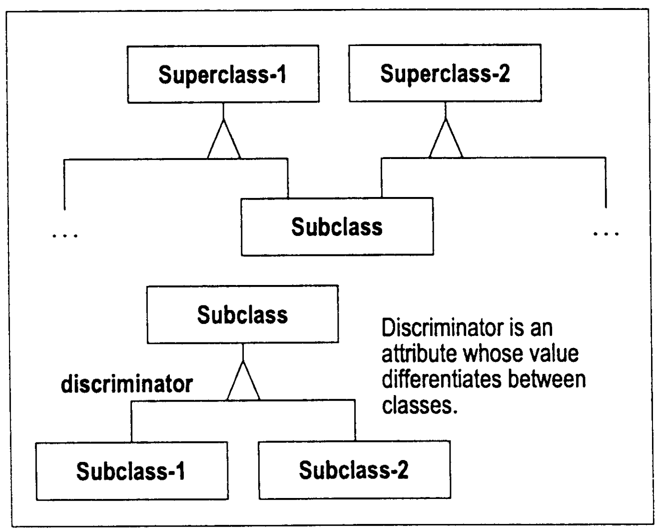

Figure 10. Inheritance is marked by a triangle.

Association is shown in four related ways, depending on the complexity of the association that needs to be represented (figure 11). The simplest form is a labeled line linking two classes. If the association is qualified, then a small box extends out from the qualifying class naming the qualification factor. For associations that call for more elaboration, there can be association classes holding either link attributes or link attributes and methods. These can be used to show complex relations, e.g., of a commander to his or her unit and assignment.

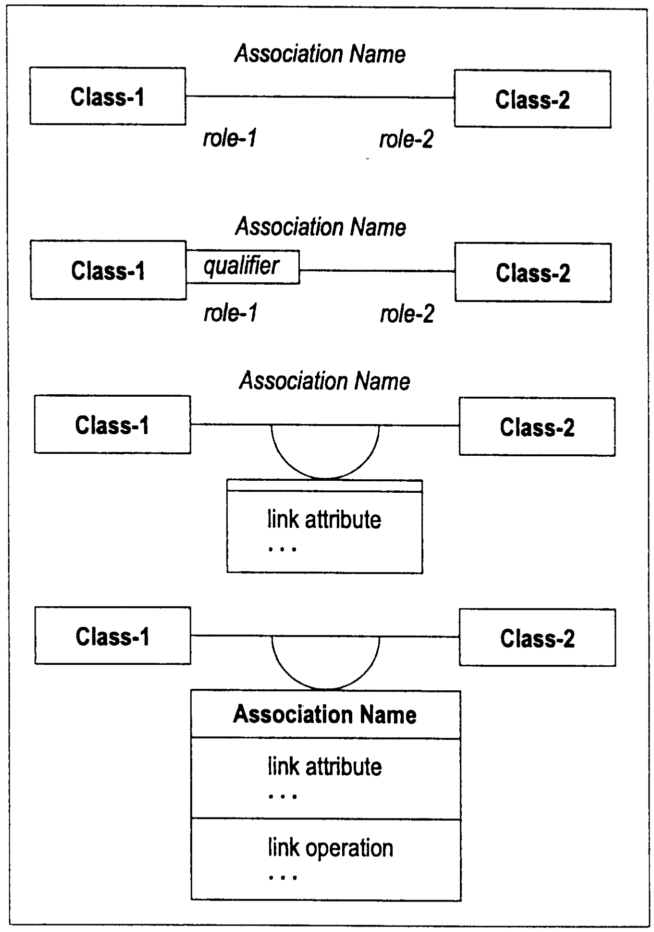

Figure 11. Associations can be simple or can be arbitrarily complex classes in themselves.

Aggregation is shown by a diamond (figure 12). Aggregation (also called composition) is used to show how components fit together into a whole. For instance, a Car class might have a Power Train, a Body, and a Make/Model through aggregation. Aggregates can be nested to whatever depth is appropriate to the subject matter. There is no inheritance through aggregation. Assuming that an assembly class inherits characteristics of its aggregated parts, or the inverse, that the parts inherit from the container, are among the most common errors made by people learning OT.

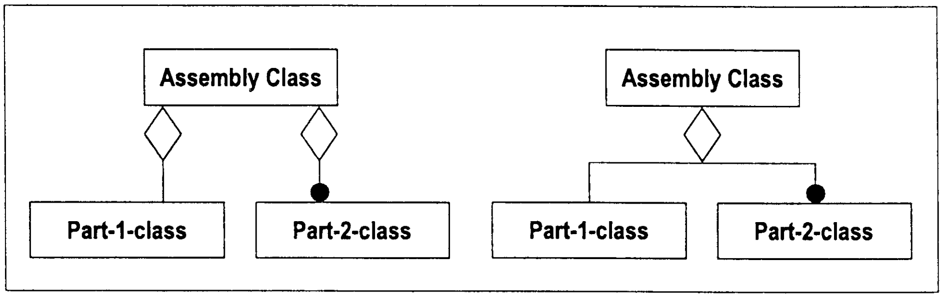

Figure 12. Aggregation is used to show assembly classes that are built with their aggregates.

Cardinality of association or aggregation allows the analyst or designer to specify exactly how many instances of the subclass should be connected to the parent class (figure 13). This can be used to distinguish necessary and optional connections. Ordered connections can also be shown, e.g., cars with either two or four doors.

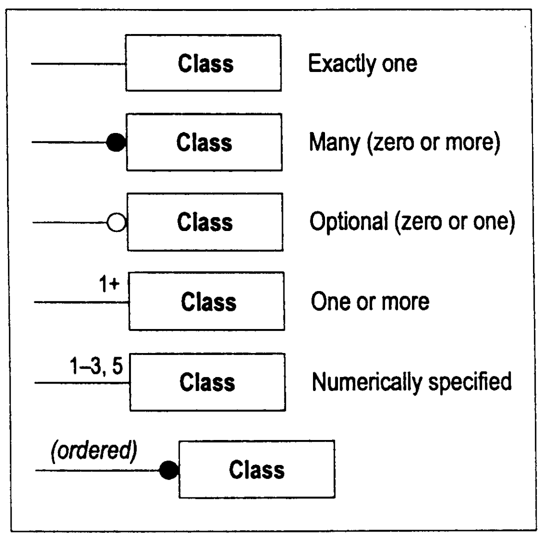

Figure 13. The cardinality of a connection can be specified.

Abstract classes are those whose instances are also classes (figure 14). These are useful to gather fairly high-level characteristics together representationally, without the specificity required for a class that has actual instances. “Platform” is an example of an abstract class. To instantiate a platform, one must move deeper into the hierarchy to specify what kind of platform is desired.

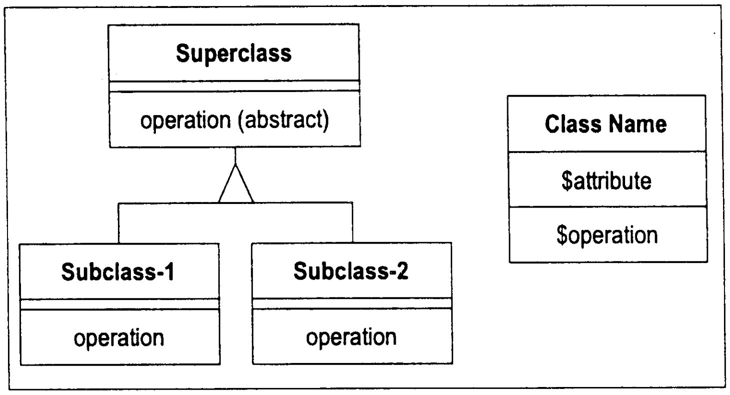

Figure 14. Abstract superclasses are those whose instances are classes.

Class attributes are attributes that belong to a class rather than to any particular instance of a class. For example, one might want to record the number of submarines in a particular model. That information properly belongs to the class Submarine rather than to any particular instance of Submarine. A class attribute is one way to manage that information.

The JWSOL program also uses Harel state transition diagrams (figure 15). Both Rumbaugh and Booch recommend them. They are straightforward; software engineers can use them immediately, and SMEs have little trouble understanding them.

Two aspects distinguish Harel diagrams from other state transition diagramming approaches. First, Harel distinguishes actions from events. Actions take place within a state; for example, “being in transit” might be a state for an Army platoon. Among the actions that could be represented within this state would be consumption of petroleum, oil, and lubricants (POL), food, spare parts, etc. Events take place at transition boundaries. The platoon’s arrival at an assembly area would be an example.

Second, Harel diagrams can be nested to recursively show different levels of events and actions. The disadvantage of this is that the specific connection between the state transition diagram and the class(es) to which it applies can be obscured. The benefit is that a very wide range of behaviors can be economically and consistently represented.

6.1.3 Single and Multiple Inheritance

There are two kinds of inheritance in object systems: single inheritance and multiple inheritance. In single inheritance, a strict (tree) hierarchy is maintained. In multiple inheritance, an inclusive (lattice) hierarchy is allowed.

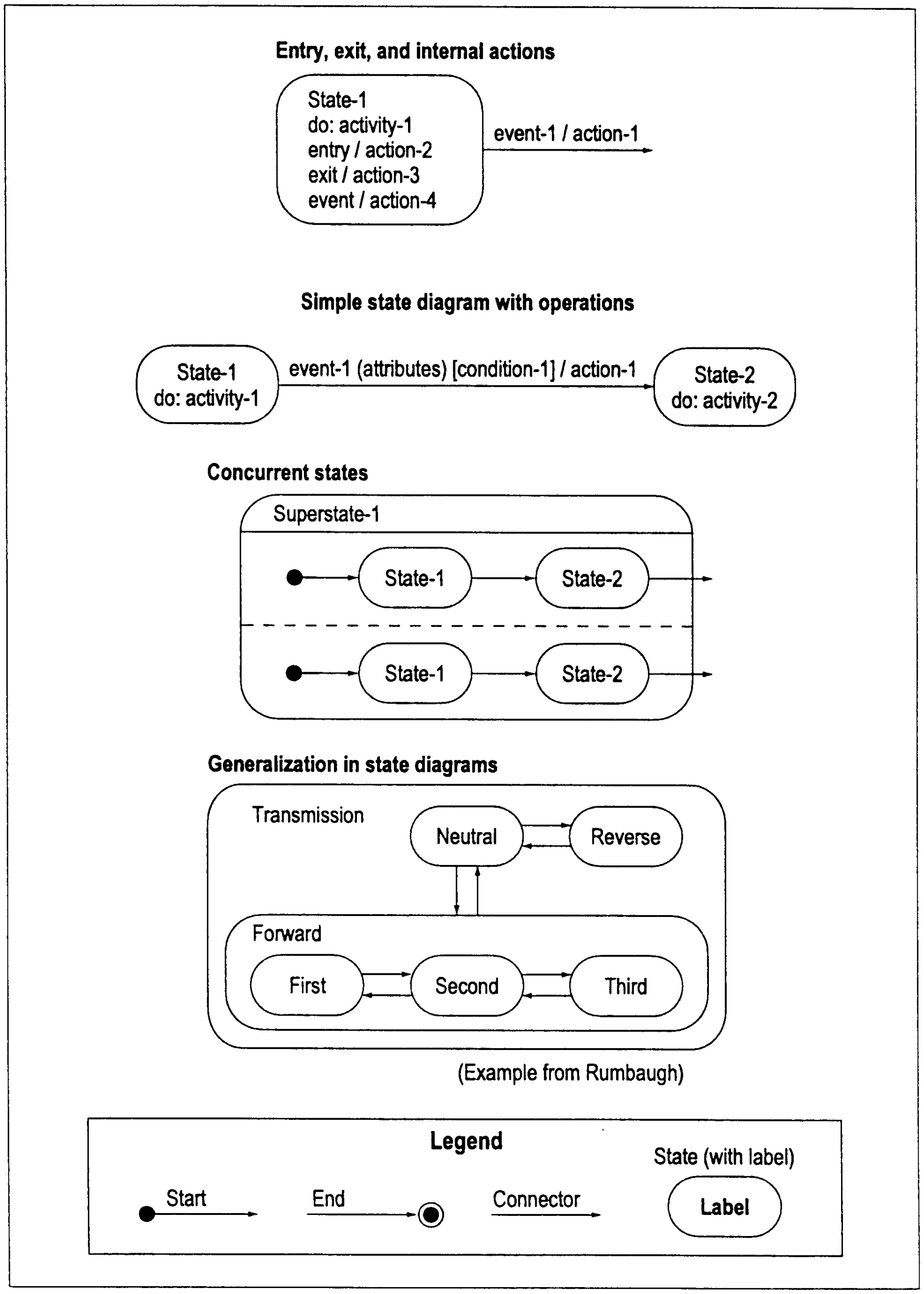

Figure 15. Harel state transition diagrams allow sophisticated representation.

Multiple inheritance adheres more closely to the "natural" OT approach taken in JWSOL. For example, a stereo system is (inherits characteristics and behaviors from) an appliance, a luxury item, and a fragile commodity. A truffle is also a fragile commodity, a luxury item, and, unlike stereos, a perishable commodity. In a multiple inheritance system, base classes for Appliance, LuxuryItem, FragileCommodity, and PerishableCommodity could be built. Both StereoSystems and Truffles, as well as Refrigerators, Eggs, and ChinaTeacup would then "fall out" of the base classes.

In a single inheritance system, a larger number of more specialized classes must be created to achieve the same representation. For example, for a StereoSystem to have the desired characteristics, a class, FragileAppliances, or perhaps even FragileLuxuryAppliances, would need to be created. The attributes that characterize fragility would need to be duplicated for each entity to which they might apply (e.g., FragileGroceries, FragileDishes).

Delegation is a method used in some single-inheritance, object-oriented programming languages to reduce this class proliferation. Using delegation, a class can assign the handling of specified messages to another class. For example, a StereoSystem might delegate messages or behaviors relevant to luxury to a LuxuryItem object. Delegation is formally equivalent to multiple inheritance but is much more difficult to administer during implementation.

Factors in favor of single inheritance include the following:

- Many people find it easier to understand.
- It is easier to optimize computationally for memory management.
- Systems built with it can be easier to maintain, although this is highly sensitive both to the design and construction of the system and especially to the subject matter the system models.

However, multiple inheritance corresponds much more directly to normal formation and use of concepts. For instance, in JWSOL a river may be a boundary from one perspective, a source of water from another, an obstacle from a third, and a means of transportation from a fourth. Each of these can and should be included. Multiple inheritance is the easiest way to represent these highly complex battlefield relationships and perspectives.

Note that this is a generic characteristic of any generally accepted class taxonomy. If, as seems possible, multiple domain-sensitive taxonomies evolve (e.g., JWSOL for theater modeling, JTF–ATD C^2 Schema for planning and for finer-grained models, etc.), then common meeting points and shared objects would achieve this objective while taking advantage of the increased power more focused taxonomies can provide.

6.2 INTEROPERATION AND OT MODELING

JWSOL could potentially support interoperability in three ways.

The first is the simplest: new models and simulations built using JWSOL objects will be able to interoperate directly. Because there will be a set of consistent common interfaces, direct object-to-object interactions within the application are both possible and natural.

If models are running on separate machines, an object request broker (ORB) would be necessary. However, there are increasing numbers of these on the market, and distributed operating systems like Cronus have been in use in military applications for some time.

The versatility of this approach is important. Because of it, independent modeling groups, associated with completely different organizations, can develop models with a reasonable degree of confidence that they will be interoperable at multiple levels (i.e., entity, plus above and below entity) once they are done.

Second, JWSOL could be used as a mediator between new and legacy models. This is dependent on work currently being explored in the Navy Simulation System (NSS) architecture, that is, the development of a model request broker (MRB). Analogous to an ORB, the MRB will manage model interactions across workspaces, nodes, and platforms. JWSOL will then provide a part of the model-level equivalent of CORBA's Interface Definition Language (IDL), that is, a model interaction definition language. Following this development approach, legacy models will not have to be directly altered to interoperate with new OT models. Rather, a model request/model service interface can be built using JWSOL (and possibly other) object definitions. Once again, interoperability will be achieved at low cost.

Third, JWSOL could use the MRB to mediate between legacy models. In this case, both legacy models will need a common-domain-object-based interface. If an MRB is achieved, interoperation can be transparent to the base legacy system. Given the current investment, this is extremely appealing.

6.3 CLASSIFICATION

Some of the problems that make creating an object-oriented taxonomy difficult are discussed here. A taxonomy is:

1. The classification of organisms in an ordered system that indicates natural relationships.
2. The science, laws, or principles of classification; systematics.
3. Division into ordered groups or categories [2].

The third definition applies, but it is briefly considered as the origin of taxonomic classification indicated by the first two. Historically, natural taxonomy began as a top-down discipline. The top-down approach starts with a category—feline, for example—and then selects and rejects according to apparent category matching. An alternate approach, bottom-up classification, was first articulated in the last third of the 18th century and was argued forcefully by Darwin (Chap. 13, *Origin of Species*). Darwin won; all current arguments in biology about classification are about variations on the bottom-up approach. Top-down "classification" is now regarded not as classification at all, only identification [6]. The point: almost all beginning taxonomists tend to classify top-down. In JWSOL, a conscious effort was made to work bottom-up, starting with the most basic elements at the level of focus (theater) and moving up in abstraction only as the content demanded.

A related error is to confuse subject areas with classes [3]. For example, in modern programs, substantial work goes into human–computer interation (HCI). This is an important subject area, and it is entirely reasonable (from a software engineering perspective) to group all of the elements that comprise the HCI into a distinct subsystem. However, it is not a class. Other than being "part of HCI," what common attributes do a window redrawing routine and a keyboard input buffer have in common? Just because one might casually "class" all of the HCI components together does not mean they are a proper OT class.

6.3.1 Ontological and Epistemological Issues in Classification

Ontology deals with "the nature of being," which may sound far removed from the pragmatic need to get things done. It is not. It has been repeatedly (and very expensively) shown that without careful examination of the ontological foundations of a particular domain, well-intentioned, energetic people can get hopelessly mired in confusion and wasted effort. If you want to get where you are going, it is a good idea to know where you are starting from. And that means knowing ontological foundations.

Epistemology is the nature of knowledge, its presuppositions and foundations, and its extent and validity. Like ontology, some epistemology is good to have because it allows a more realistic assessment of the problems of taxonomy-building and the validity of the product.

The following paragraphs describe the fundamental ontological problem, review some epistemological problems, and then describe the simple but powerful ontology used to organize the taxonomy.

First, ontologies are human constructions, and they vary from domain to domain. Lehrer [8], following Perkins [10], describes four interrelated features of knowledge—the first two are ontological (the second two are epistemological and will be covered shortly):

- Knowledge is constructed pragmatically, incorporating human purpose to serve human ends.
- Knowledge is structured. Purpose and structure are interwoven; structures serve purposes.

The implication is that perspective is intrinsic to any ontology. To make this more concrete, put yourself in the role of an SME and think about how you would decide whether two classes should be on the same level of abstraction. For most people, the instinct is to place things with relatively equal importance to the domain (relative to significant events and actions) at the same level. This constrasts with, say, examining the relative complexity of items as reflected in their intrinsic attributes. But the idea of "intrinsic attributes" is thorny. How would you decide, and by what criteria, which attributes, at what level of representation, are both intrinsic and germane for a given subject area? A chemist and a logistics planner are not likely to identify the same set. Attributes are selected as relevant according to our goals. No goals, no attribute selection criteria; therefore no taxonomy. With goals, we get a taxonomy, but we also get a perspective. The ontological message: perspective is fundamental, not accidental.

Having to embody a perspective is not a problem for highly focused, narrow user-base ontologies. In fact, it is a source of strength and economy of representation. However, JWSOL is intended to support a wide range of users, with a wide range of views.

Before stating the ontology, one needs to look at the fundamental epistemological problem: the world is not made up of ideal categories. There typically is not a single, "pure," knowable identity for any given thing. To understand this, here are Lehrer's second two points:

- One's knowledge includes models or cases that exemplify its structure. This enables communication, development of mental models, and reasoning.
- Knowledge should include some means of developing and evaluating arguments (i.e., should contain some way to develop validation criteria).

When the current set of models and cases is unconsciously generalized from experience, the true nature of a class is obtained. Evidence from cognitive psychology, especially the work of Elanor Rosch [summarized in 7], suggests that the "true" nature of a class is a mental construction. For example, everyone knows what a bird is. But which is more "birdlike," a robin or a turkey? A finch or an ostrich? When people are tested for recognition of "birds," they are significantly faster at identifying robins and finches than turkeys and ostriches.

Everyone knows there are no "birds" out there, just specific individual birds that humans find it convenient to classify together. The important point is that in this classification of natural kinds, classification is done by prototype, not by the logician's necessary and sufficient conditions. Placement of any individual in a class involves judgment, not simply mechanical sorting.*

This is the epistemological side of the ontological problem. There, it was perspective; here, it is judgment. Once it is seen that placement of individual examples into classes is essentially (and not

* The judgment can get arbitrarily complex. If Fido loses a leg in a car accident, he is a three-legged individual, but he is still a dog, and therefore is a four-legged mammal.

accidentally, provisionally, or artifactually) a matter of judgment, then the taxonomist is obligated to justify that judgment.

One fundamental problem with taxonomic classification remains—namely, how are you classifying? By function? By attributes? By probable or possible consequences? By actions? In OT writing, there is an insistence on preference for attributes, especially over functions (which are more prominent in traditional software design). This sounds reasonable, but it is not always a clear-cut distinction. Function influences which attributes are important or, in the case of manufactured items, even what the attributes are. As seen above, purpose and structure are interwoven. So, the distinction between what something is and what it does is valuable and rightly emphasized by OT authors, but it is far from definitive.

Figure 16 shows the JWSOL ontology. The top row shows the basic organizing perspectives. The middle row shows the drivers for evaluation, that is, for understanding the meaning of the current situation. The third row shows the elements that evaluation is based on. The overall picture shown in the executive summary (figure E-1) falls out of this ontology.

EVENTS	AGENTS	OBJECTS
GOALS	STANDARDS	ATTITUDES
CONSEQUENCES	ACTIONS	ASPECTS, QUALITIES

Figure 16. JWSOL ontology showing organizing perspectives, evaluation drivers, and evaluation elements.

7. TAXONOMY

This section presents the JWSOL taxonomy. The charts illustrating the hierarchical relationships and text describing the rationale for the structure are provided. Additional details on attributes and methods are included in appendix A.

7.1 HIGH-LEVEL OVERVIEW

The discussion of ontology (section 6.3) described the use of an Agent/Object/Event paradigm for taxonomic classification. This section shows and discusses each of the top-level elements, along with discussion of their relationships.

The term “Physical” rather than “Object” is used in this section. All of the elements discussed in the taxonomy are potential objects in the OT sense. Using Object for just one subtree invites confusion.

7.1.1 Physical

Physical is what people normally associate with “objects”—ships, boats, planes, communications equipment, etc. The JWSOL taxonomy also includes a broad class of environmental elements within Physical.

7.1.2 Event

An Event is something that happens. In the past, events were predominately represented within state transition diagrams. They are still represented that way; however, recent thinking, e.g., Martin and Odell [9], has suggested elevating them to the status of classes. This makes sense. Many events have natural subclassing—missions are an obvious military example.

7.1.3 Agent

“Agency” is the core unifying idea linking people and organizations. Both can properly be said to have goals, desires, motivation, intentions, and plans. Agents initiate actions to pursue goals. If you can appropriately think about it as having intentions, it is an Agent [4].

Since reasoning by cause is far more important than other kinds of reasoning [11], being able to model humans and organizations is critical. We universally posit goals and motivation to reason about causes of events.

The JWSOL taxonomy has two broad cases of Agent, Human and Organization (see section 7.4). Their relationship, i.e., aspects of human roles that lie essentially in a person’s relationship to an organization, are modeled via an association class.

Organizations are modeled as structures, subclassed shallowly according to predominant mode of activity. This is possible because the internal structure of Organization recurs without significant change at multiple levels.

Organization is intended to represent groups of people acting together, “group” being arbitrarily large or small. It may even be the case that for some modeling or planning needs the group may consist of a single individual. For example, it may be preferable to model the truck bombing of the Marine compound in Beirut as being performed by the Hez’bollah even though a single person perpetrated it.

Command and Control is the “glue” that combines the Physical, the Event, and the Agent. In a military context, it is the knowledge infrastructure that is learned and handed down through generations of experience from leader to leader, through schooling and training as well as through standard procedures and policy. It is the decision-making policy, the physical decision-making chain from top to bottom, and the feedback that goes back from the bottom to the top. It includes the people, chain of command, the physical communication infrastructure, and historic events that have framed decision making by leaders. It is the appropriate use of centralized and decentralized control, where appropriate, that permits the vast, both in size of force and sphere of influence, U.S. political/military team to participate effectively in world current affairs.

The root of the top three superclasses, Agent/Physical/Event, has a ternary association class called Command and Control that relates the three classes at the top of the JWSOL taxonomy (figure 17).

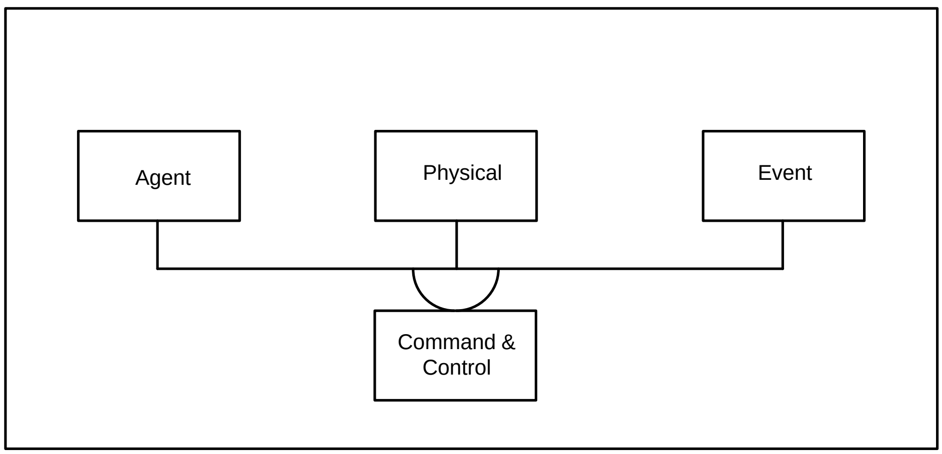

Figure 17. JWSOL taxonomy.

7.2 PHYSICAL SUBTREE

The physical subtree has eight classes of materiel warfighting objects, plus the environmental objects Natural and Artificial (figure 18). Although most of the classes obviously fit within this subtree, the rationale for inclusion of others is not so self-evident. For example, sensors, communications, and countermeasures are most often thought of as capabilities or parts of a land vehicle, aircraft, or vessel. But they are physical objects that have common attributes when included on a platform, as well as specific attributes depending on its type of employment (i.e., air, land, or sea).

7.2.1 Materiel Warfighting Objects

Communications has two subclasses, Equipment and Networks, which are composed of both nodes and links (figure 19). The links consist of courier, relay, and line, and the nodes consist of telephones, computer equipment, and different types of radios.

Aircraft has two major subclasses, Fighting and Transport/Payload (figure 20); this operational mission view was chosen for the classification structure. Fighting is further broken into Attack, Fighter, Bomber, EW, C^2, Reconnaissance, and ASW. The Transport/Payload subclass consists of aircraft supporting the functional mission areas of Supply, Aeromedical Evacuation, Personnel, Special Ops, Combat Rescue, and Air Refueling.

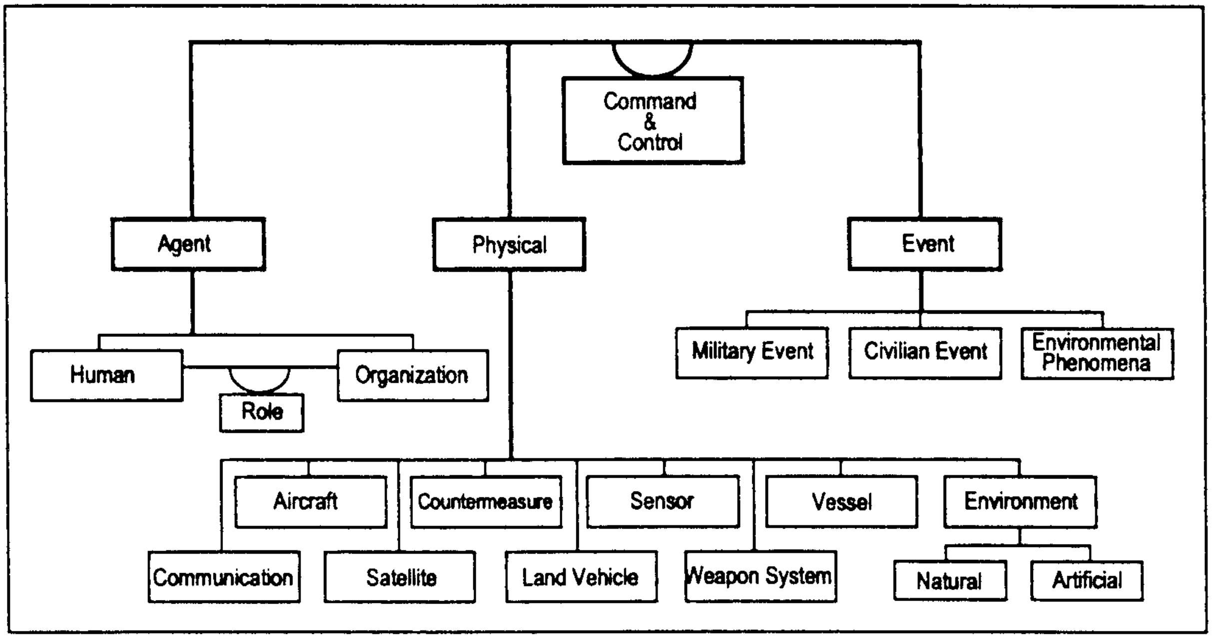

Figure 18. Physical subtree.

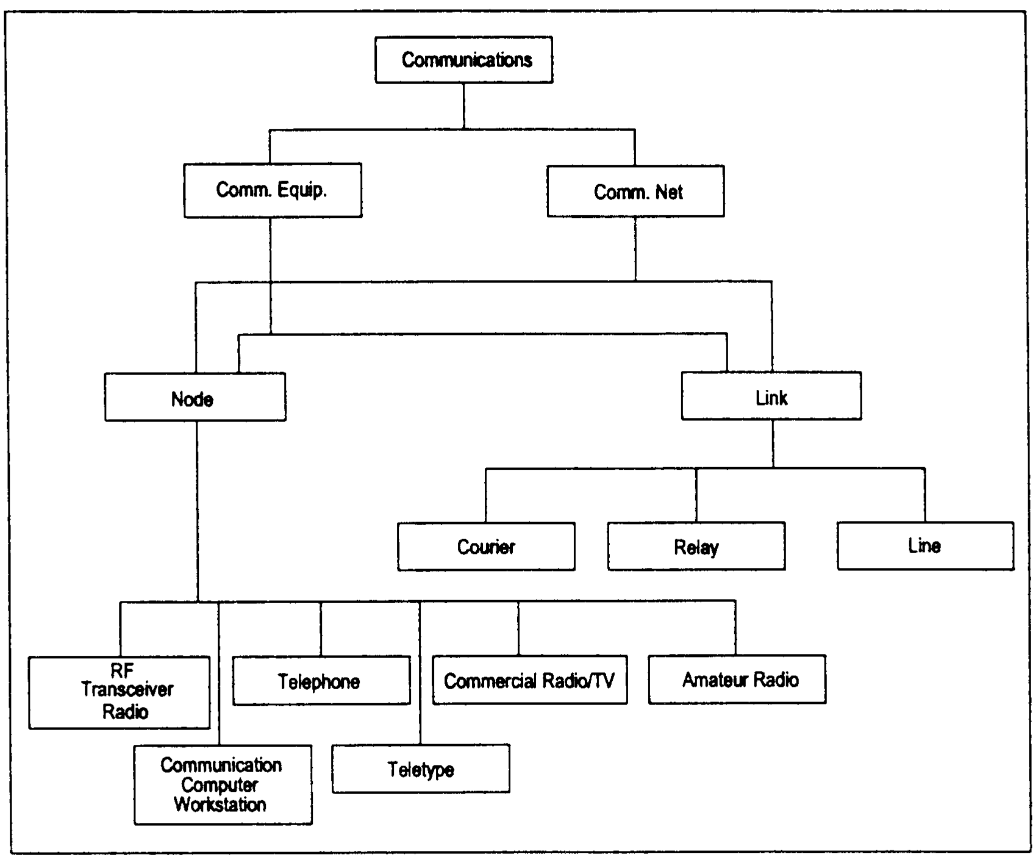

Figure 19. Communications class.

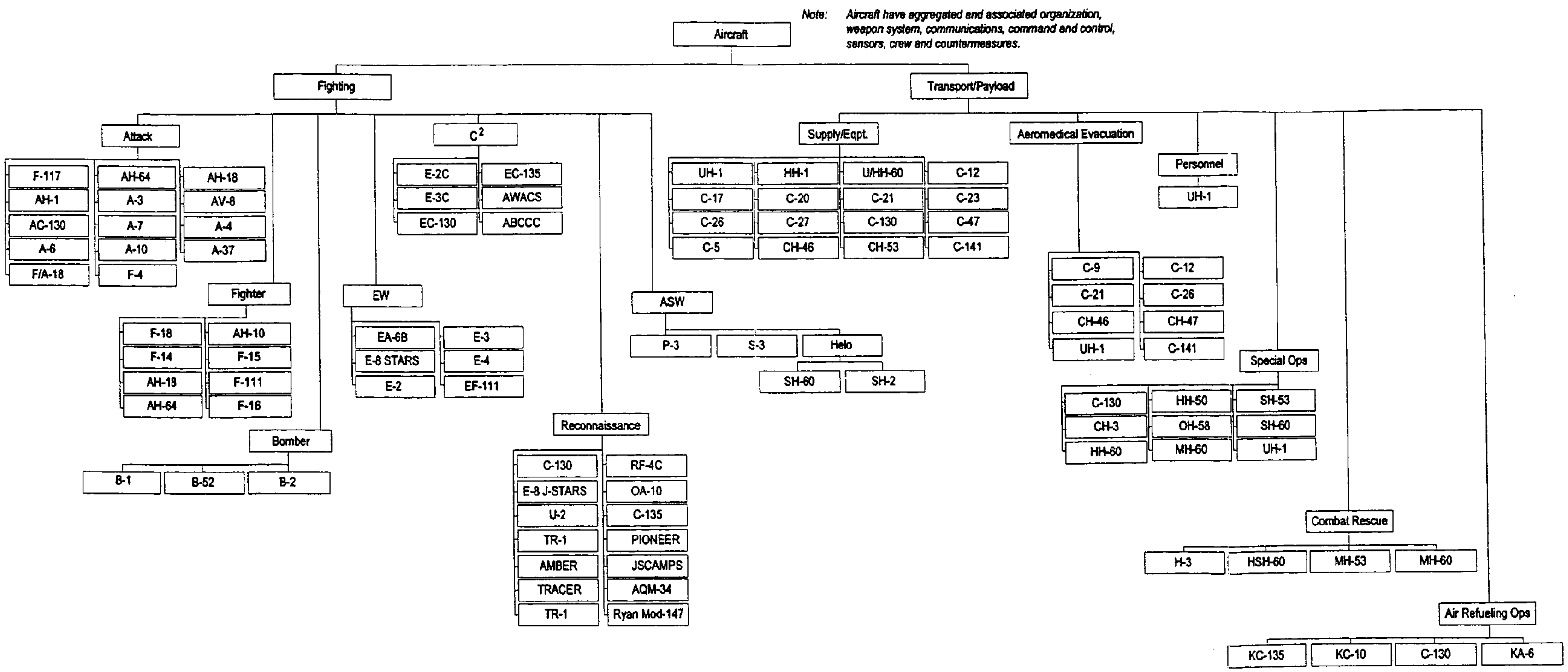

Figure 20. Aircraft class.

Countermeasure has five major subclasses: Prairie Masker, Visual/Optical, Decoys, Chaff, and Jammers (ECM) (figure 21).

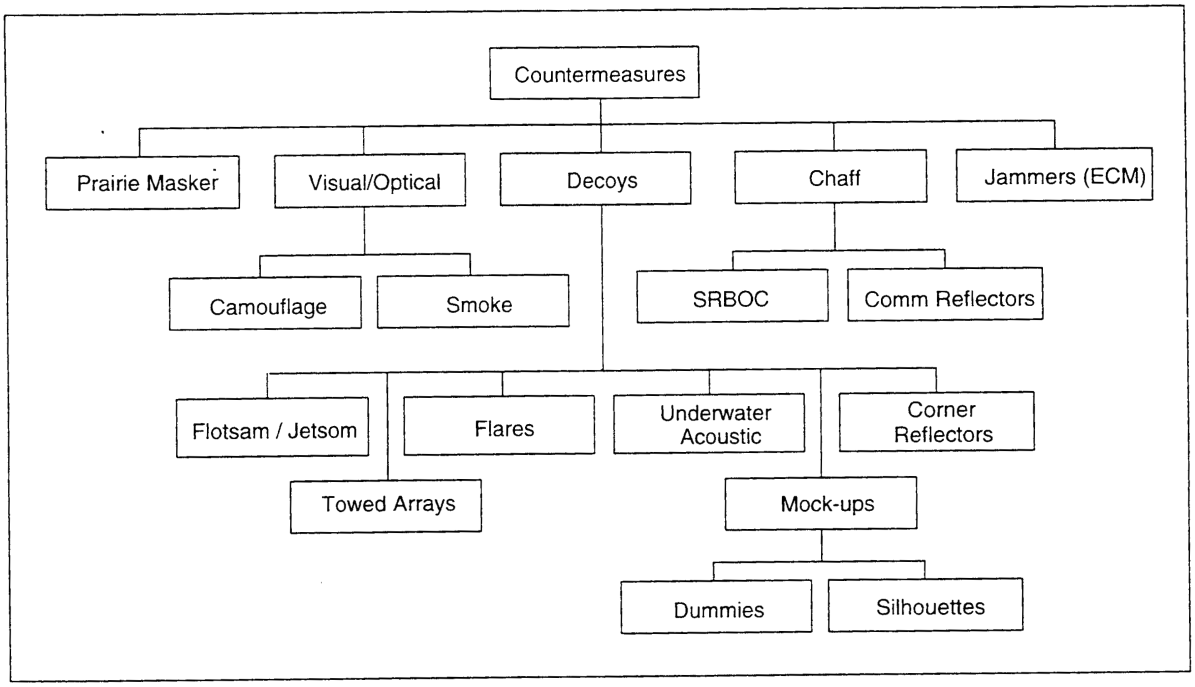

Figure 21. Countermeasure class.

Land Vehicle has three major subclasses: Fighting, Engineering, and Transport (figure 22). Land vehicles, like aircraft and vessels, have an aggregated and associated organization, weapon system, communications, command and control, sensors, crew, and countermeasures.

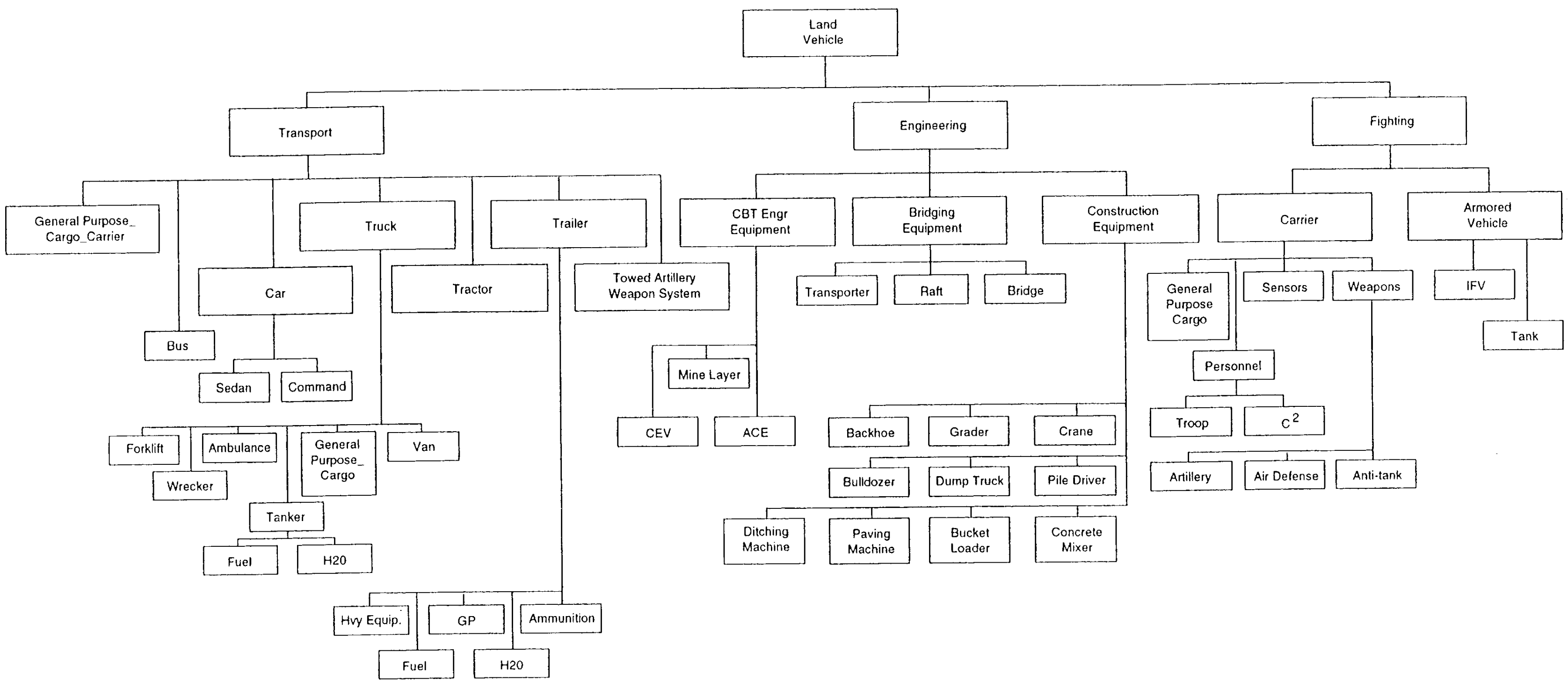

Figure 22. Land Vehicle class.

Satellite is a platform that has associations that contain Communications and Sensors (figure 23).

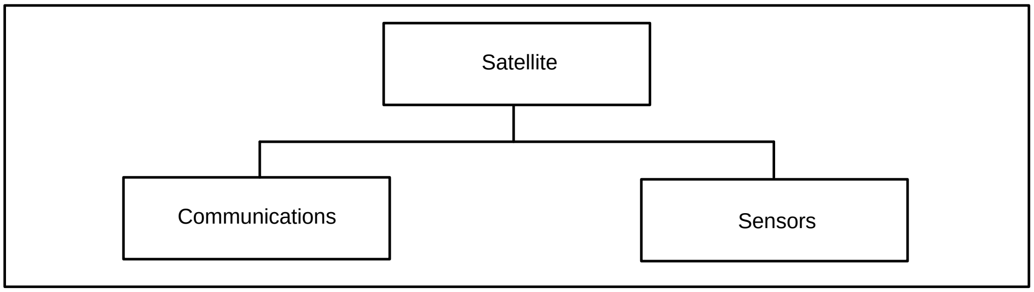

Figure 23. Satellite class.

Vessel has three major subclasses, Fighting, Support, and Transport (figure 24). Vessels have an aggregated and associated organization, weapon system, communications, command and control, sensors, crew, and countermeasures.

Weapon System has five subclasses, Missile/Rocket, Bomb, Gun, Mine, and Torpedo (figure 25).

There is an explosive payload association between the ASROC class and the Bomb and Torpedo classes (figure 26) for the appropriate payload.

Sensor has two major subclasses: Active and Passive (figure 27).

7.2.2 Environment

The JWSOL Environment taxonomy subtree follows the Dynamic Environmental Effects Model (DEEM) approach of providing much more explicit and complete modeling than usual. This is important for three reasons.

First, increasing computational power and growth in distributed computing makes it possible to model the environment with greater resolution and accuracy than has been true in the past. This will lead to more consistent models and other applications of the taxonomic objects. Many legacy systems model devices and platforms in excruciating detail, but then model their operating environment in the most trivial way, except in some very-fine-grained one-on-one engagements and underwater models. This casts doubt on the reliability of the models. JWSOL will be able to support correcting this problem.

Second, environmental concerns are increasingly real in military planning and operations. Recall the smoke plumes and 20-mile oil slick resulting from Iraq's "ecoterrorism" in the Gulf War. Or consider the status of the many nonfunctioning Russian nuclear submarines. Direct modeling of, and planning regarding, these kinds of environmental issues is increasingly important.

Third, having access to detailed environmental classes and objects makes adaptation of planning and modeling to new operations faster and more reliable. Food delivery in Rwanda, house-to-house fighting in Mogadishu, peacekeeping in Haiti: none of these are tradiational applications of computer-based support for modeling, planning, or training.

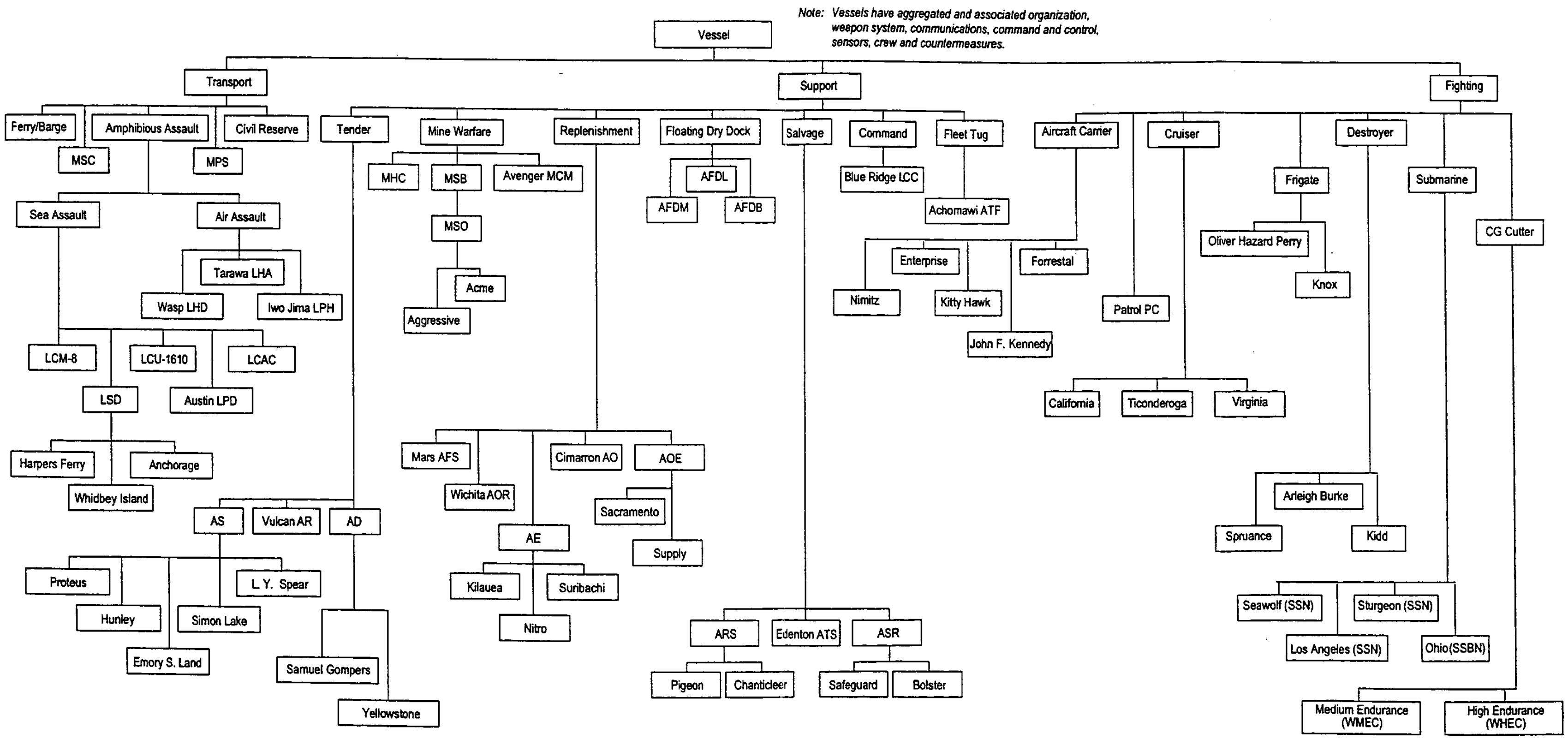

Figure 24. Vessel class.

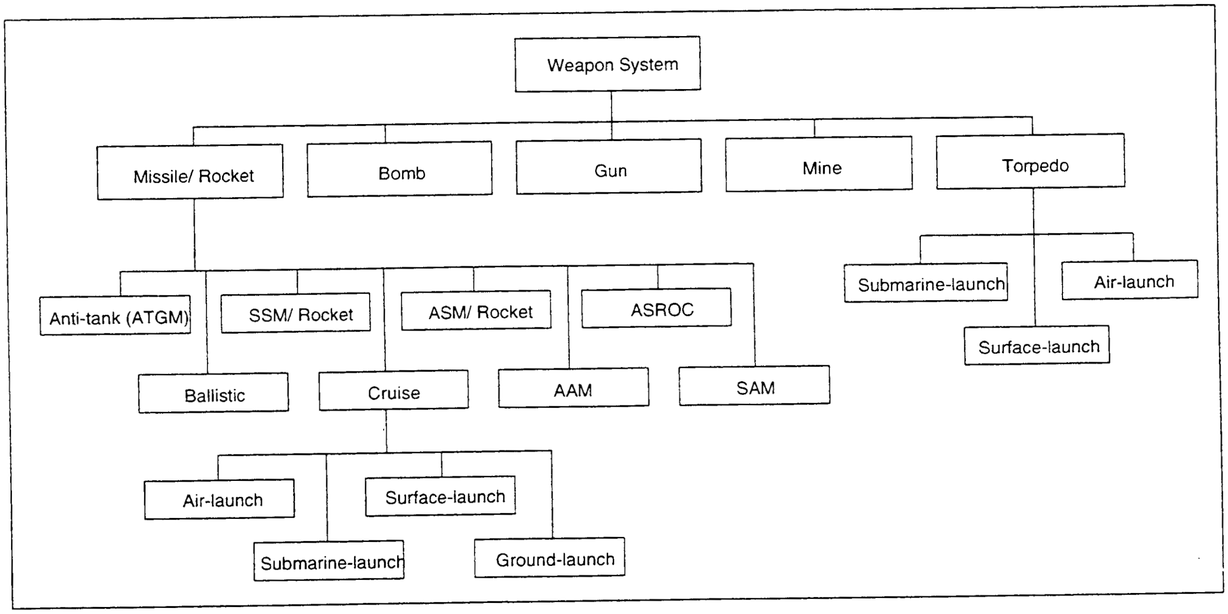

Figure 25. Weapon System class.

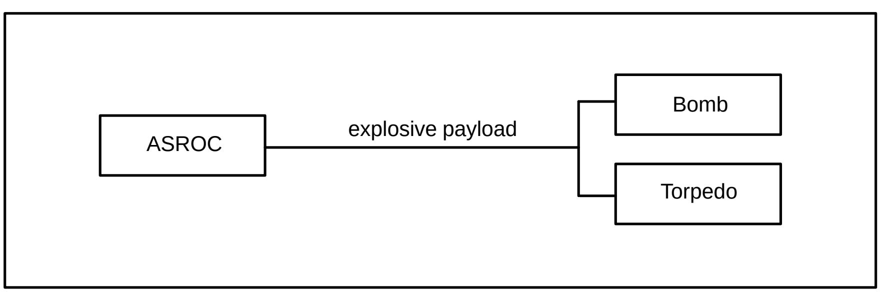

Figure 26. ASROC association.

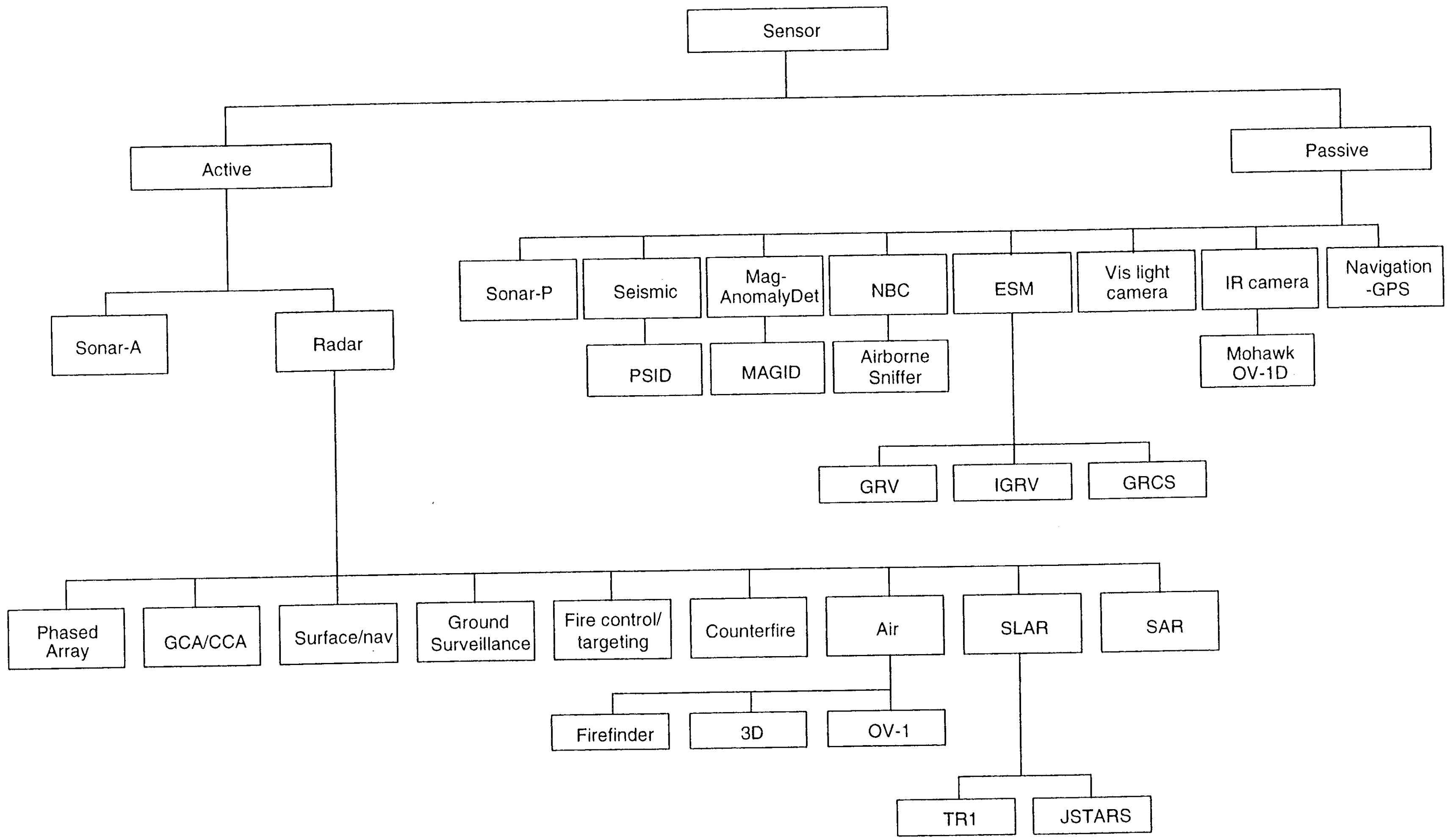

Figure 27. Sensor class.

Figures 28 through 33 show the JWSOL taxonomy for the environment. Figure 28 shows a top-level view of the primary subclasses that make up the JWSOL environment. At the top-most level, the environment is divided into Natural and Artificial classes.

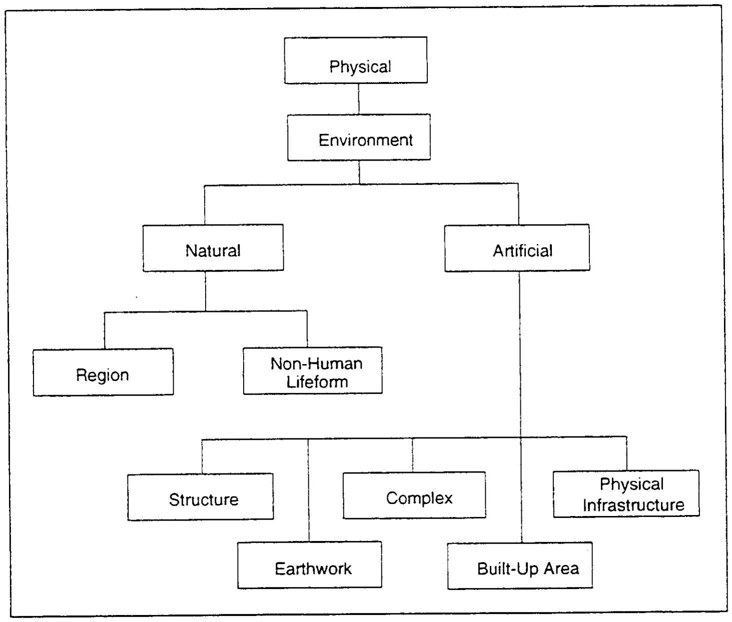

Figure 28. Environment superclass with two subclasses—Natural and Artificial.

Appendix A includes detailed Rumbaugh drawings of all of the environment objects including attributes. The level of detail provided for the environment is high and consistent with that provided with the other JWSOL objects. For example, information on the vegetation characteristics of a section of terrain is required to calculate the travel times of a force moving toward a given objective. This kind of detail is provided in the JWSOL environment taxonomy.

7.2.2.1 Natural Environment. Natural Environment is divided into two classes: Region and Non-Human Lifeform. Regions are the "traditional" components of the earth-atmosphere system: land, ocean/sea, air, and space. Non-Human Lifeform is divided into Plant, Animal, and Virus.

The Land taxonomy, as shown in figure 29, is based on that used by DEEM. Land is subdivided into Surface Cover, Soil Cover, Snow Cover, Drainage Cover, and Topography objects. Surface Cover describes the surface characteristics of a specific piece of land, and the specific categories are based on those used in DMA's Interim Terrain Data (ITD) specification.

The Topography object describes any topographic feature that can be found on land. Topography is divided into features: Point (e.g., a crater), Line (e.g., a river bed), and Area (e.g., mountain range). This taxonomy is general and avoids having to deal with vague terms like "hill."

The Ocean/Sea object, also shown in figure 29, denotes the major oceanic components of the earth and is described in a way similar to Land. (Inland bodies of water like the Great Lakes, the Caspian Sea, etc., are handled under the Open Water object under the Land Region object.) There is an object to encompass the actual water, and there are objects to describe the sea bottom and littoral area. As with the land, the sea bottom also has a topography object to describe the topographic features that are found.

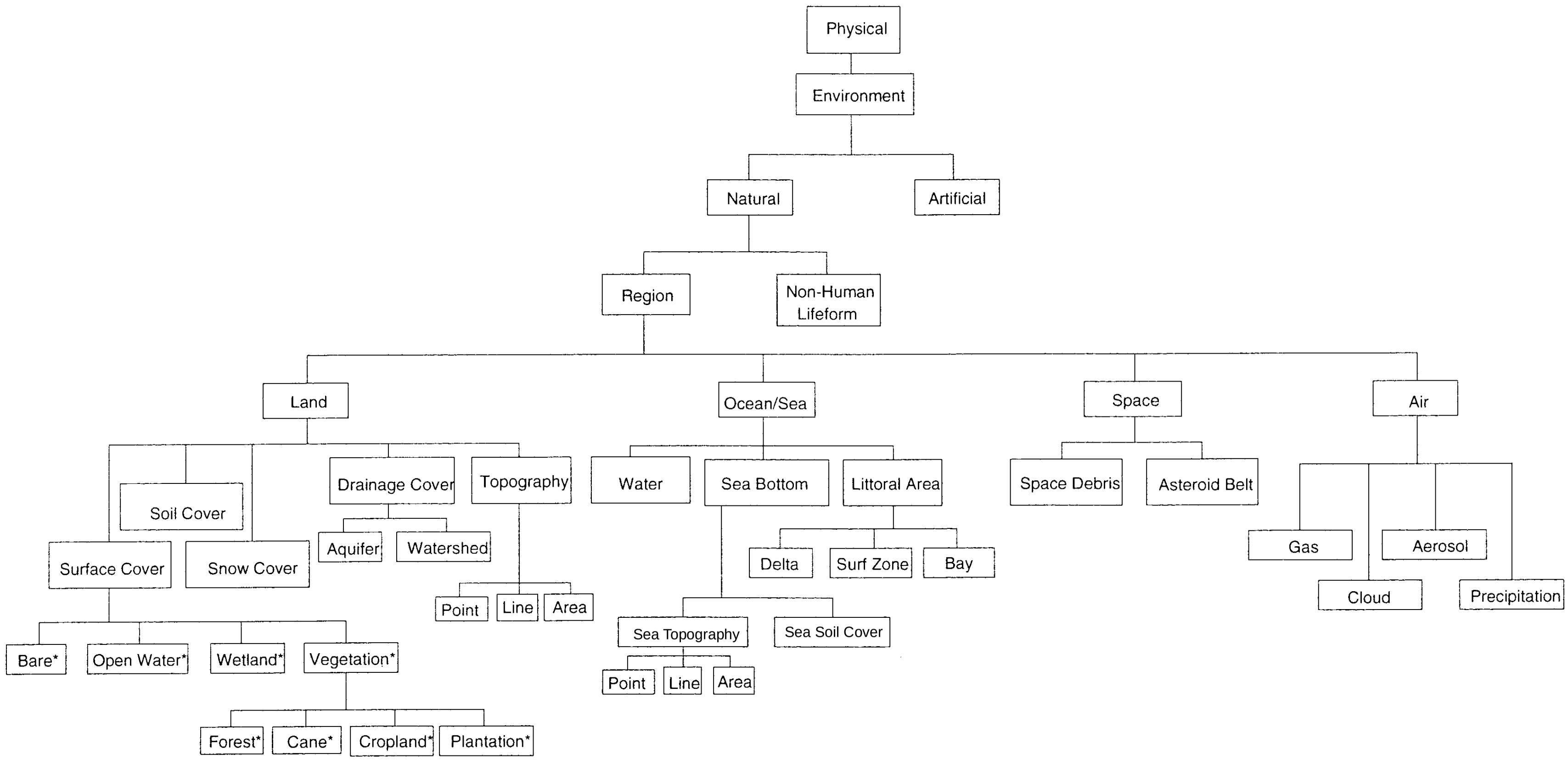

Figure 29. Natural Region class.

Originally, water that would be found on land, like rivers and lakes, was included under a more general "water" object. Later, these were put under the Land Region object. The reason is that these bodies of water are generally fed by dynamic hydrological processes on the land (e.g., runoff) and that the spatial extents can be highly variable. For example, rivers can dry up or they can flood. Therefore, although one can identify a river bed on a piece of land, one cannot always be sure of identifying the extent of the water that is flowing down the riverbed.

To account for this, a "nominal" Open Water object represents that portion of a land surface "normally" covered by water. An example would be a river or a small lake. Tied to this object is another object, the "nominal" bottom object that represents the river bed, for example, over which the water is flowing. The nominal bottom object has attributes like those of an exposed soil. In a way similar to the Open Water object, there is a snow (or ice) cover object that represents a surface that would normally be covered by snow or ice.

In the "real world," open water on land and snow involves highly dynamic processes that can change quickly. This object taxonomy for the environment is designed to allow for these kinds of dynamic variations; i.e., rivers can dry up or flood.

The Air region is simply divided into basic components in the atmosphere: gas, aerosol, cloud, and precipitation. Originally, the Air region was to be divided into atmospheric subregions, such as boundary layer, troposphere, and stratosphere, but this was rejected for three reasons. First, this differentiation might not be understood by the layperson. Second, because these layers are defined by basic differences in the underlying physics of the atmosphere, no general boundaries could be assigned to these layers. Third, no benefit would be gained for any simulation by adding these layers.

Figure 30 shows the Non-Human Lifeform objects. The Animal object has three subclasses: Pet, Wild, and Livestock. These classes are further subdivided into aquatic and terrestrial objects. The Plant object is divided into Woody and Herbaceous, which are further subdivided into Aquatic and Terrestrial.

7.2.2.2 Artificial Environment. The Artificial environment, shown in figure 31, consists of those tangible objects or artifacts built by humans. Examples are any type of structure that can be built. The objects found in the Artificial environment are related to the Natural environment in that they are found in some region of the Natural environment. The building materials used in their construction can also be made from components found directly in the Natural environment, such as soil, as well as those that have been processed from materials found in the Natural environment, such as wood or metal.

The Structure object describes any structure that can be built. In this version of the JWSOL taxonomy, the Structure object is divided further into Building, Bridge, Tunnel, and Pole/Tower objects. Each one of these objects is then described in terms of the fundamental components: Section, Panel, Support, Trim, Opening, and Membrane. From these components, any type of structure can be built. The use of the structure (e.g., a dwelling, office building, etc.), is considered to be an attribute. This approach has been used successfully within the DEEM effort to incorporate munitions effects against buildings in an urban warfare simulator.

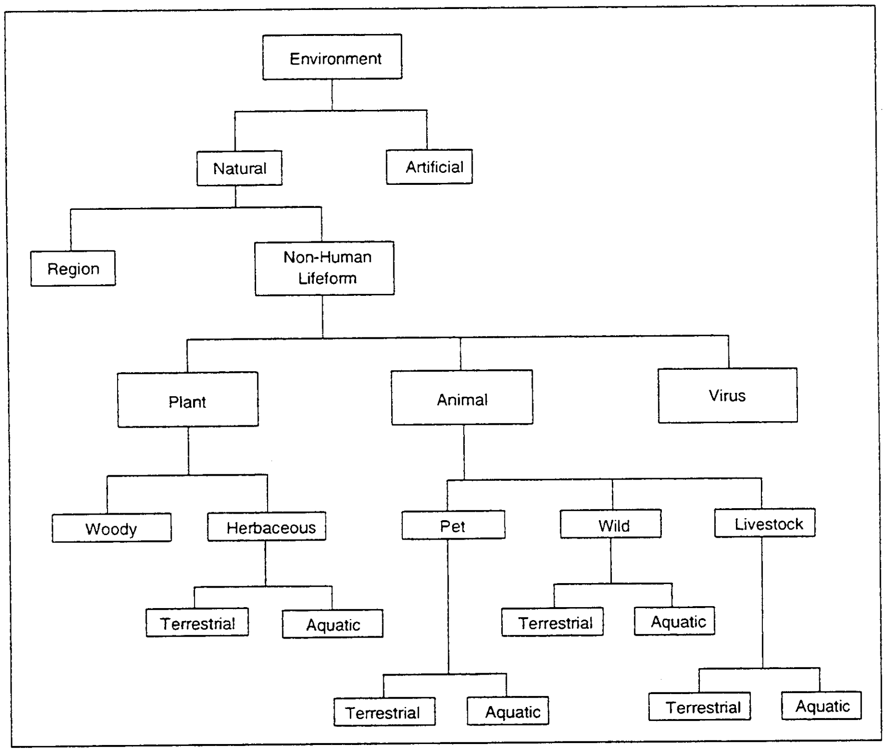

Figure 30. Non-Human Lifeform class.

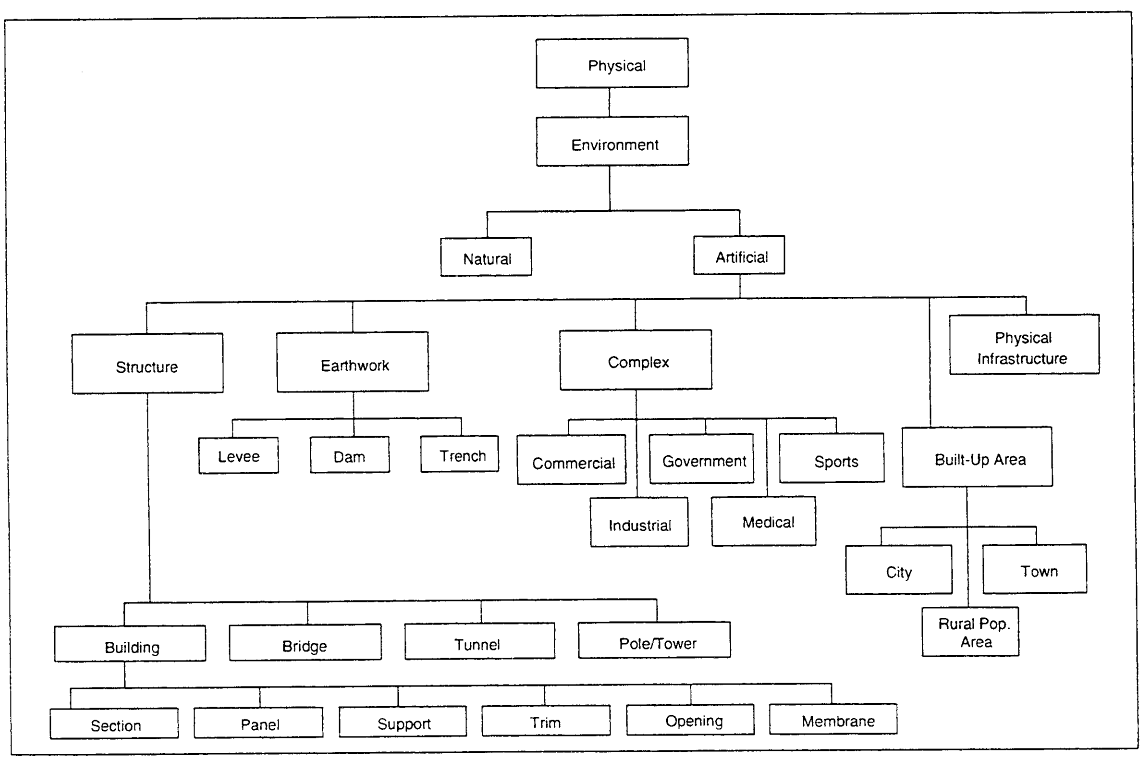

Figure 31. Artificial class showing Structure, Earthwork, Complex, and Built-up Area subclass.

The Earthwork object consists of any artificial feature built on the land, such as levees, earthen dams, dikes, and trenches. These objects would be associated with land features and may appear as either line or point features on a map. Each of these objects is assumed to consist of earthen materials. For example, if a trench had a concrete lining, the cut in the soil would be under the Earthwork class, while the concrete lining would be described as a structure.

Complexes are described in terms of their primary use, such as industrial site or medical facility. On a map, complexes would be denoted as either point or area features.

A complex would normally have a series of structures associated with it. The structures can be complicated buildings that could be found in an industrial complex, or a simple parking lot that could be found at a recreational complex.

The Built-up Area object denotes any area where humans live. The built-up areas can be classed further in terms of general demographic categories, such as rural, city, and town.

The Physical Infrastructure object, shown in figure 32, describes the objects that provide needed services to the environment, such as transportation, utilities, and energy. The transportation infrastructure is described in terms of rail, road, water, and air components. Each transportation component is described in terms of a net, nodes, and links. The Utility/Energy object is used to describe the networks, nodes, and links required for the distribution of services, such as water, sewer, power, and telecommunications. The Air Link subtree shown in figure 33 has attributes and methods for two subclasses, Airway and Military Air Corridor.

7.3 EVENT SUBTREE

The Event Subtree has three primary objects: Military Event, Civilian Event, and Environmental Phenomena, as shown in figure 34. The objects that this subtree represents are temporal. The Engagement class of Military Event has 17 subclasses covering Air-to-Air through Subsurface-to-Subsurface engagements.

The Civilian Event object denotes nonmilitary occurrences. Most of the subclasses are politically or economically based.

The Environmental Phenomenon object describes significant events that shape what happens. Events have a distinct temporal and spatial nature in that they occur over a fixed time and occur at a given location(s). Using this definition, the Environmental Phenomenon objects are described in terms of Biological, Meteorological, Geological, Sociological, Astronomical, and Hydrological, as shown in figure 34. The spatial extent over which a phenomenon has no definitional limitations should be noted. For example, a sunspot can result in disruption to an entire telecommunications network. (The spatial extent will be entirely driven by the context of the simulation being performed.)

Also, an Environmental Phenomenon of a specific type can spawn one or more of another type. As an example, an undersea earthquake (Geological Environmental Phenomenon) can give rise to a tsunami (Hydrological Environmental Phenomenon) that could trigger a tidal wave (Sociological Environmental Phenomenon) when it reaches land.

7.4 AGENT SUBTREE

The Agent Subtree has two primary objects, Human and Organization, shown in figure 35. An association class called Role relates Human to Organization.

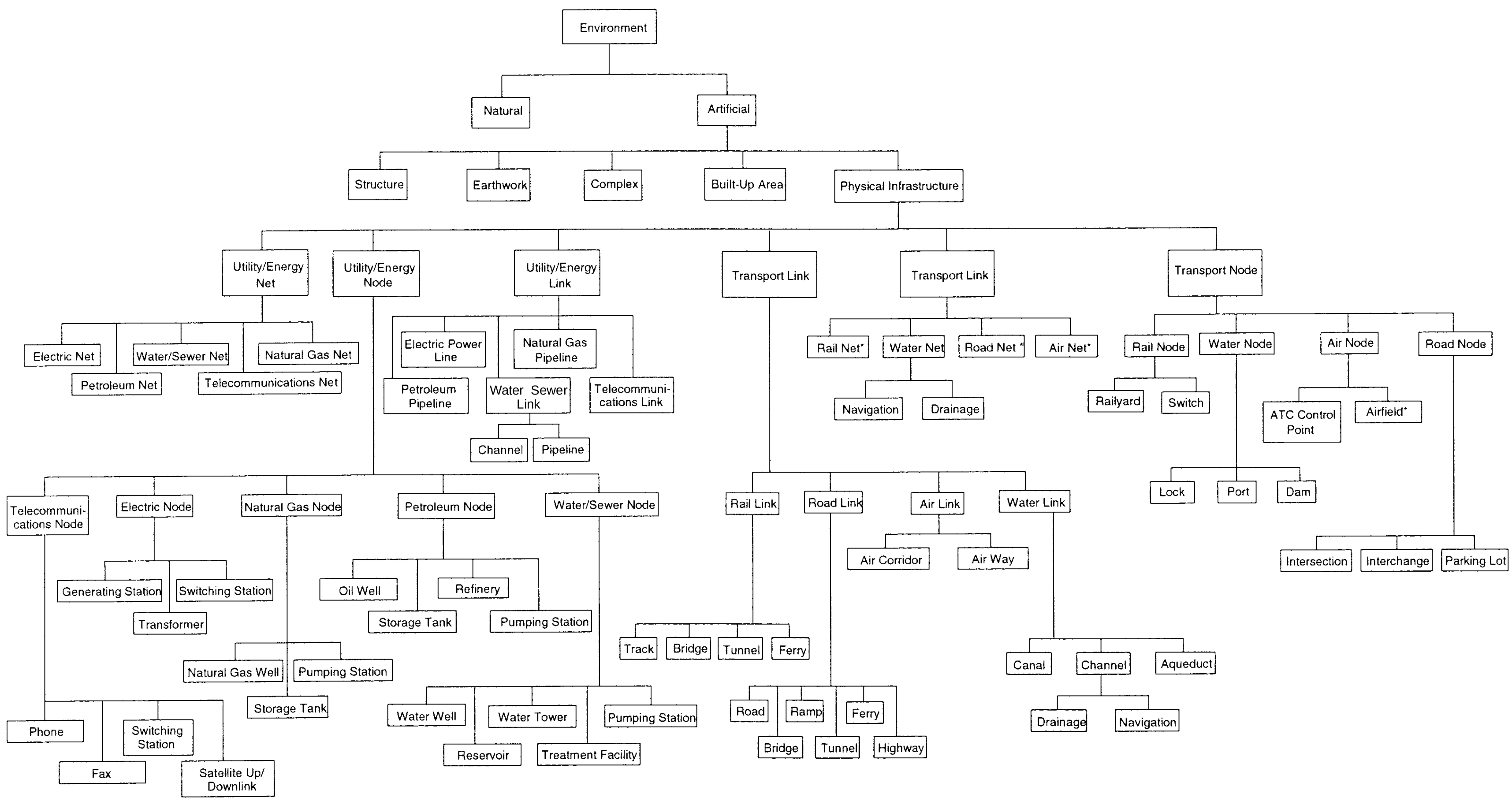

Figure 32. Artificial class showing Physical Infrastructure subclass.

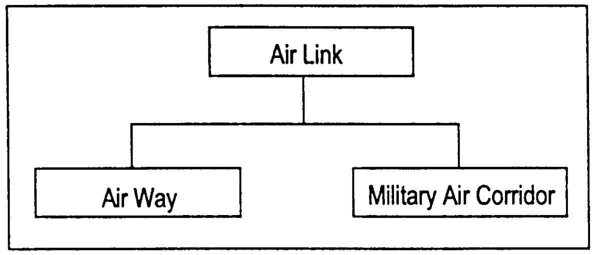

Figure 33. Air Link subclass.

7.4.1 Human Subclass

The Human subclass has attributes such as Profession, Skill, Degree of Proficiency, Sex, Age, Language(s), and Special Physical Characteristics.

7.4.2 Organization Subclass

As mentioned above (section 7.1.3), organization is intended to represent groups of people acting together. “Group” can be arbitrarily large or small. It may even be the case that for some modeling or planning needs the group may consist of a single individual. For example, it may be preferable to model the truck bombing of the Marine compound in Beirut as being performed by the Hez’bollah, even though it was performed by a single person. Organization has three subclasses: Military Organization, Non-Military Organization, and Crew. Note that, as currently conceived, small groups of humans, e.g., a crew, are modeled as a subclass of Organization, with which individual Humans may be associated. They are modeled by associating Human with Crew through the Role relationship.

7.4.3 Role Subclass—Human Subclass and Organization Subclass Relationship

People are represented by the Human class and participate in an Organization class. Role is the association that gives a person a definition within an organization. Some roles derive from the ability of the individual considered alone. Doctor, lawyer, and software engineer are examples. Other roles derive from an individual’s relationship to an organization (figure 36). Speaker of the House and prisoner are examples. A Human can perform in many roles depending on the situation. For example, a CEO of a Private Organization, like a company, will be in the leadership role for that Private Organization—Human Association. The same CEO may be a member of another Private Organization that is philanthropic and where he performs in the role of fundraiser.

Since in the great majority of circumstances JWSOL will need to model, people are associated with organizations, it seems appropriate to use association classes to model those roles determined by the relationship. The content of the association class is sensitive to role and to kind of organization. For example, the links to a Private Organization might include the attributes Mission, Type_of_PrivateOrg, Industry, Name, Union_NonUnion, Person_in_charge_name, Person_in_charge_title, Successor, Structure, Location of HQ, Alternate HQ, Field HQ, Permanent Address, and Branch Address, for example. Humans relate to their “home” organization through association classes. Otherwise, it is a direct association.

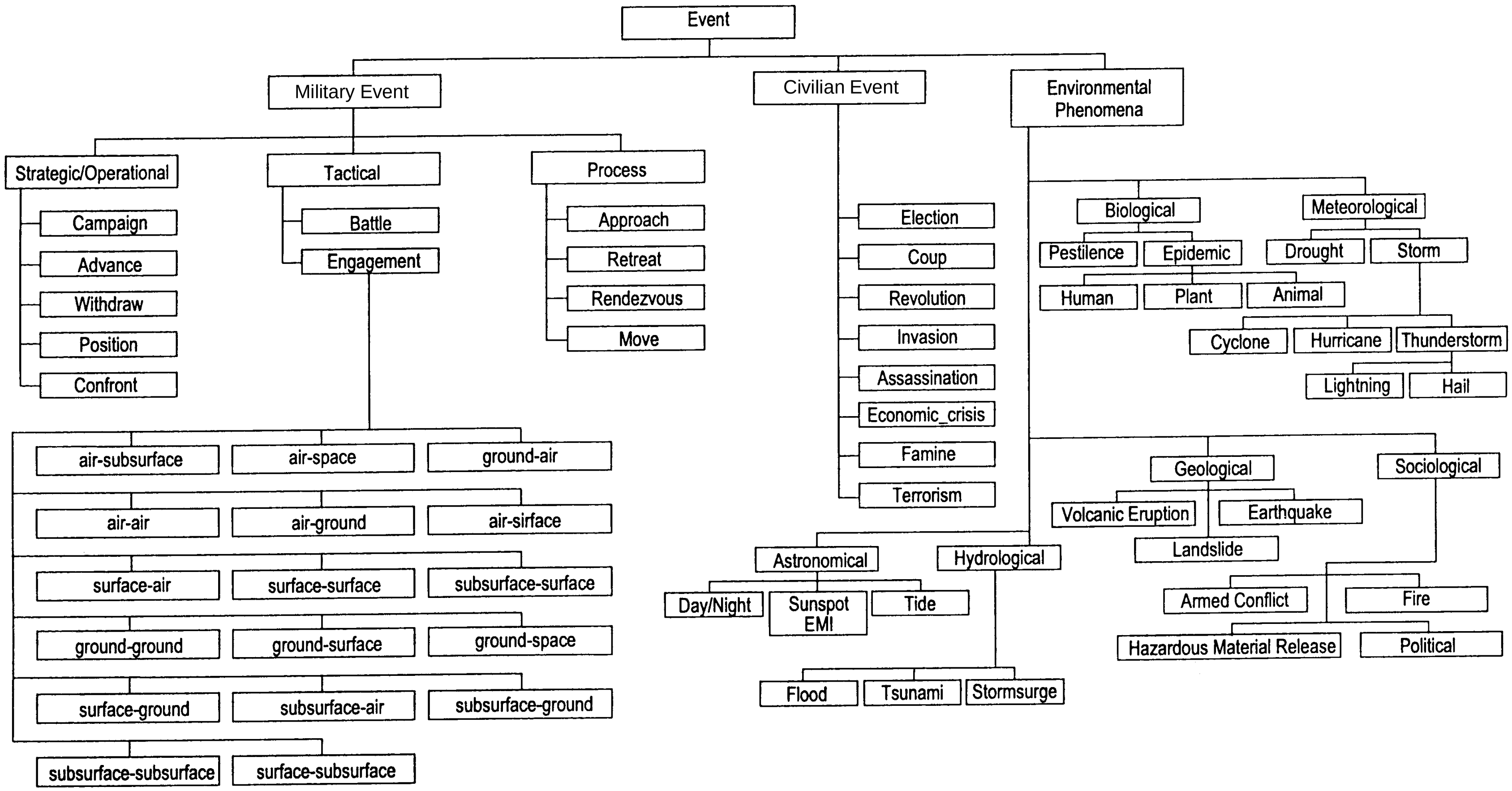

Figure 34. Event class.

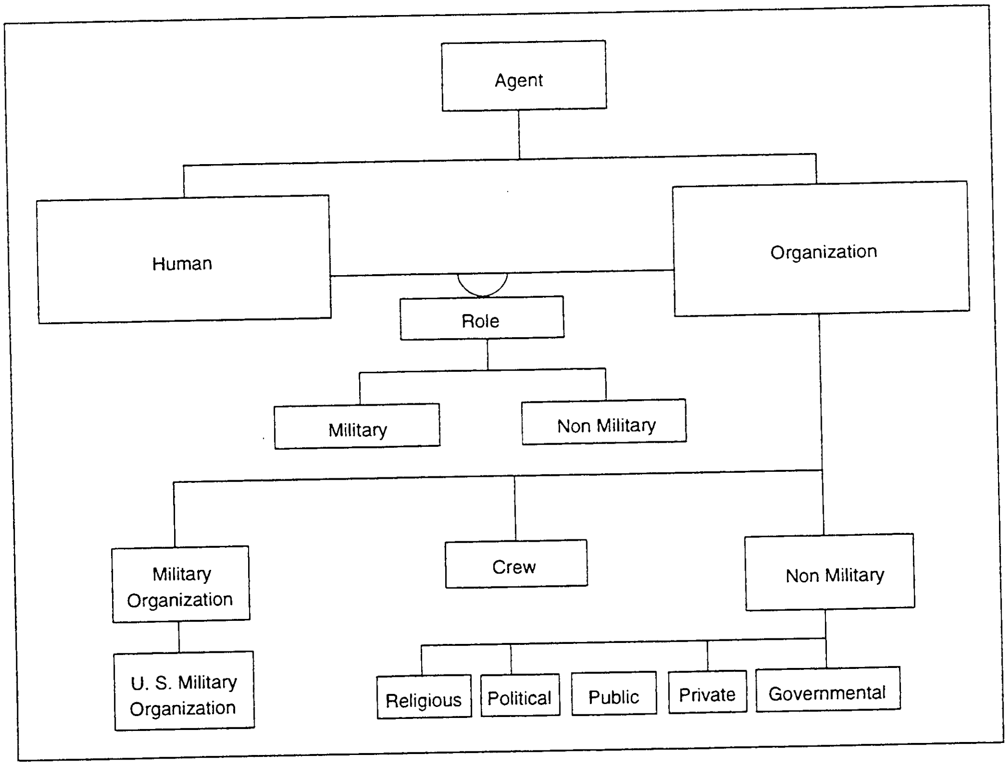

Figure 35. Agent subtree with Human and Organization.

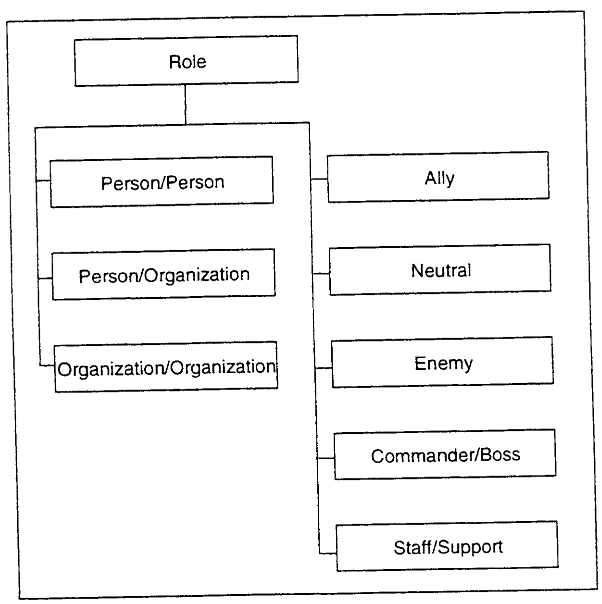

Figure 36. Role class.

People and organization are the most interesting and important things a Commander of a joint task organization, such as a Joint Task Force, will consider. Agent is the core unifying idea linking people and organizations. Both can properly be said to have goals, desires, motivations, intentions, and plans. Agents initiate actions to pursue goals. If you can appropriately think about it as having intentions, it is an agent (AFSC Pub. 1, *The Joint Staff Officer's Guide* 1993, National Defense University, Norfolk, VA).

Some Non-Military Organizations will have subclasses based on mission or purpose of existence. For example, a private organization that has a mission to provide services would be classed as a Service Organization (e.g., Kiwanis, Rotary, and Optimist) (figure 37).

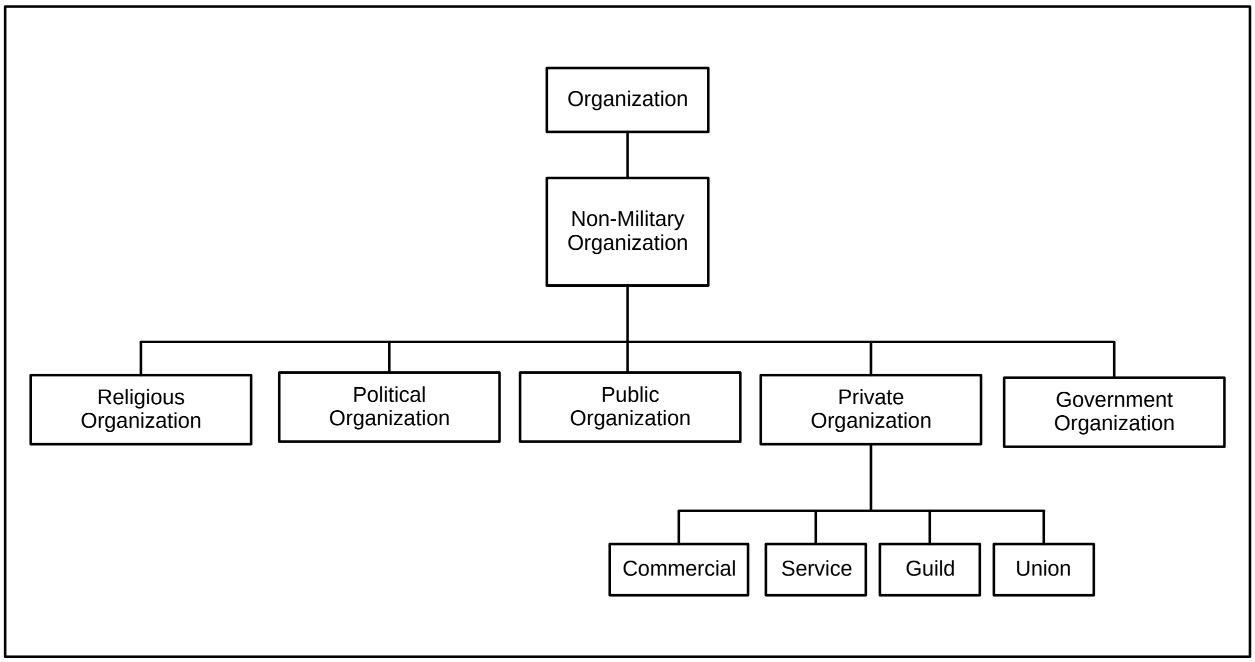

Figure 37. Non-Military Organization classes.

The Military Organization, shown in figure 38, is divided into the U.S. Military Organization class and Other Military Organization.

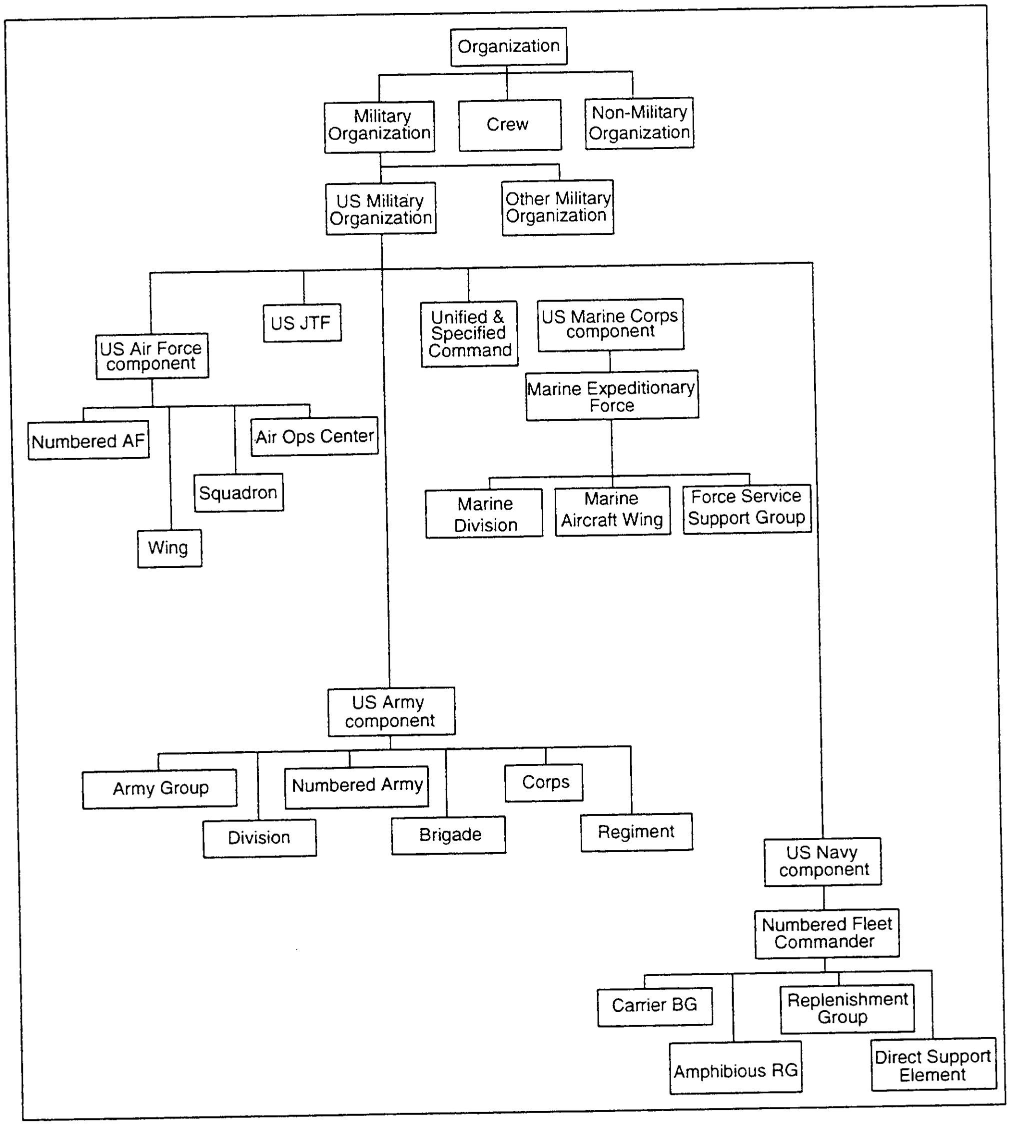

Figure 38. U.S. Military Organization.

The Army component could perform a mission requiring a corps organization with an assortment of major combat, combat support, and combat service support units of division, brigade/regiment, and separate battalion size. Such a corps would be categorized as "heavy," or "light mixed," and could be organized using a unique selection of units, as shown in figures 39 through 41.

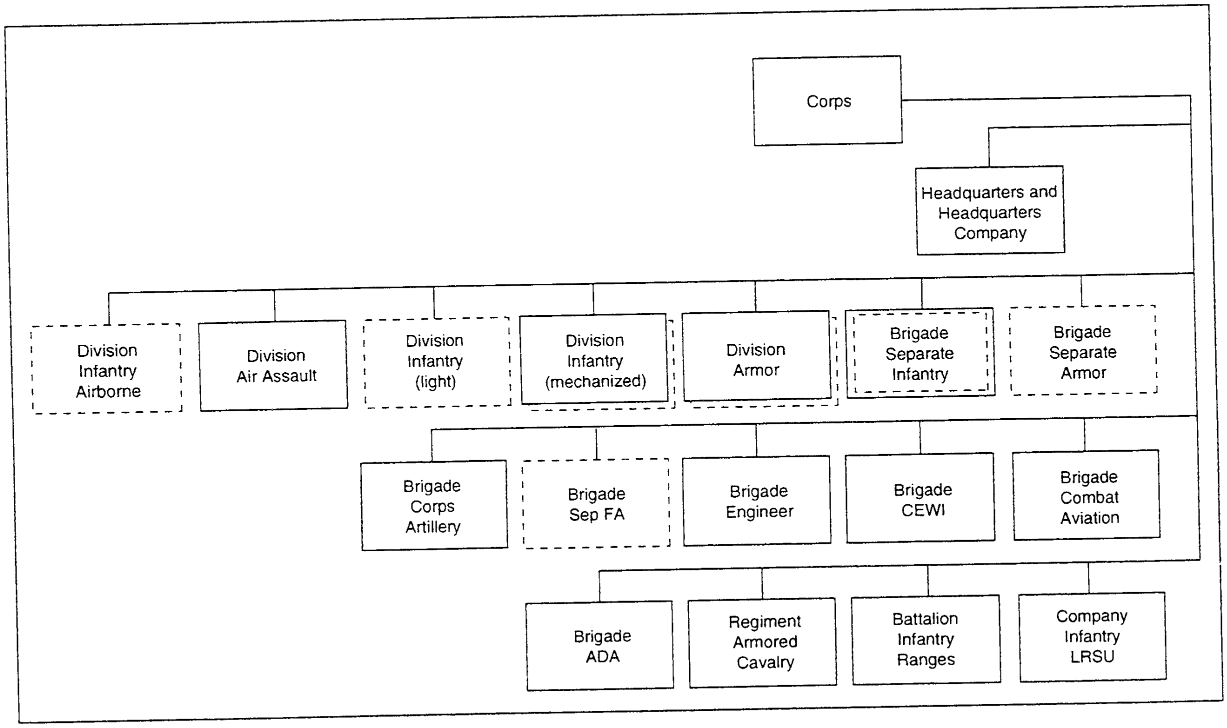

Figure 39. Army component Corps class.

The Air Force component is task organized to accomplish a specific mission. The organizations are identified in figure 42.

The U.S. Navy component is task organized to accomplish a specific mission. The Battle Group organization is composed of physical ships (vessels) that are organized to accomplish a warfighting mission. The Battle Group class includes Carrier, Destroyer, Frigate, and Submarine (SSN) assigned, as shown in figure 43.

The U.S. Aircraft Carrier class, shown in figure 44, has five subclasses: USS *Nimitz*, USS *Enterprise*, USS *John F. Kennedy*, USS *Kitty Hawk*, and USS *Forrestal*. The Human warfighter complement attribute and the number of berths available per platform are two attributes of interest to the theater CINC.

The U.S. Cruiser class has six subclasses: USS *Virginia*, USS *California*, USS *Truxton*, USS *Ticonderoga*, USS *Belknap*, and USS *Leahy*, as shown in figure 45.

The U.S. Destroyer class has three subclasses: USS *Spruance*, USS *Kidd*, and USS *Arleigh Burke* (figure 46).

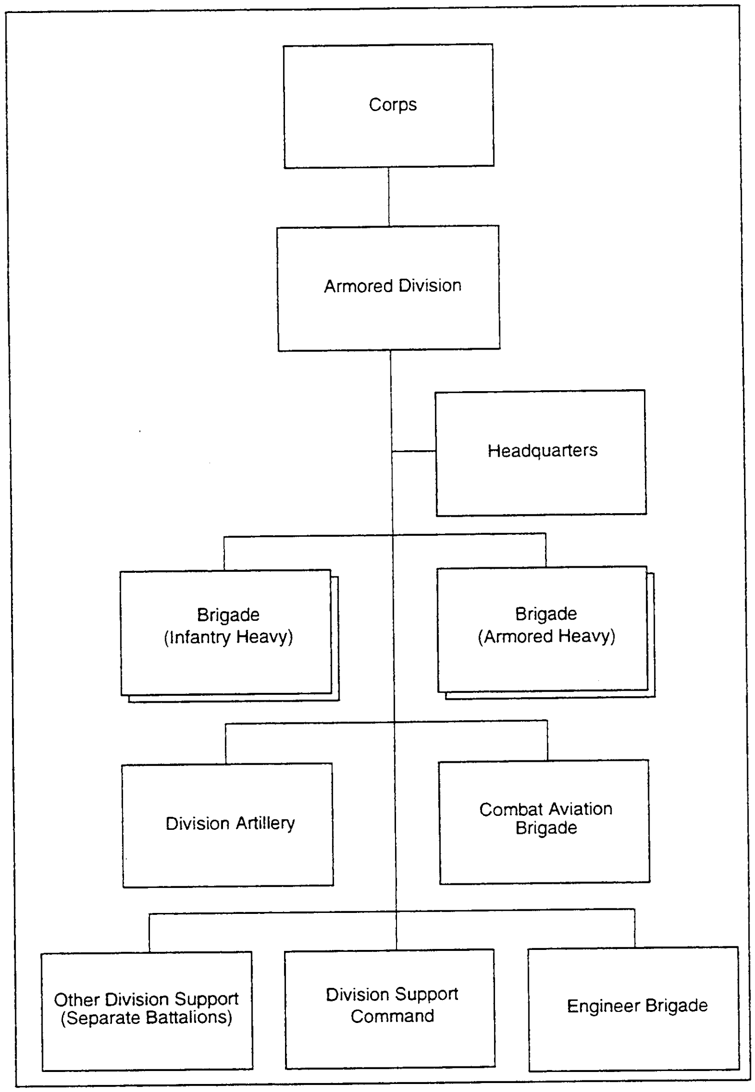

Figure 40. Armored Division.

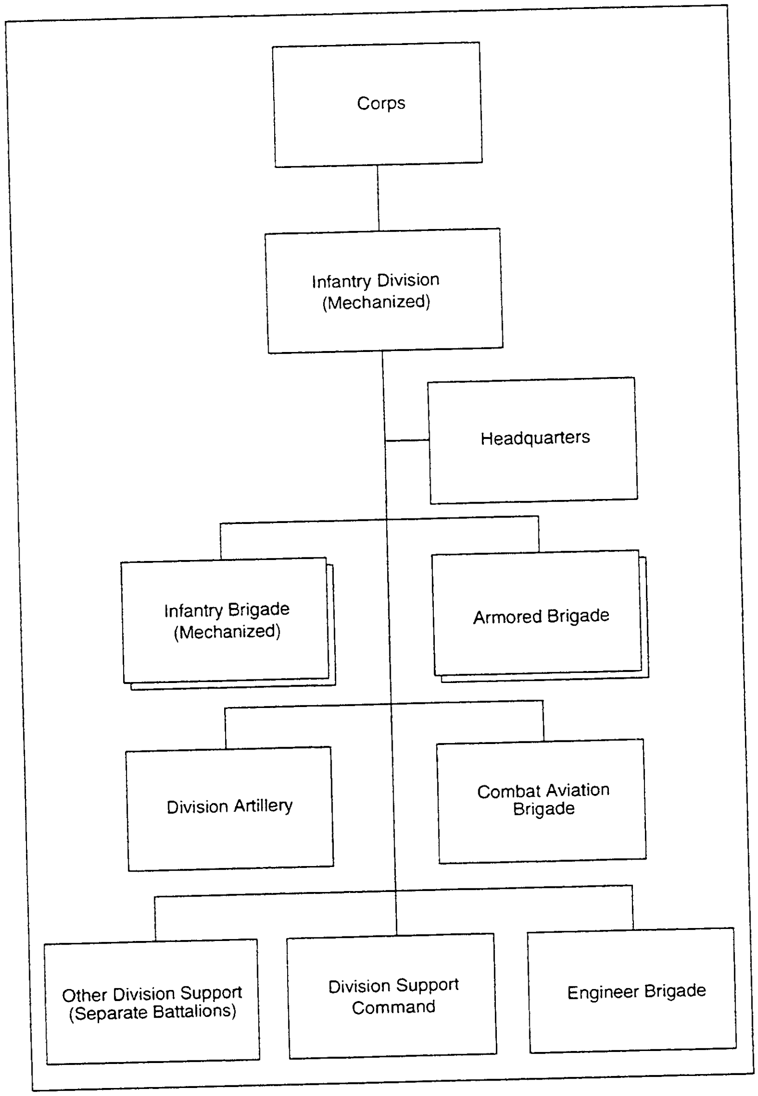

Figure 41. Infantry Division (Mechanized).

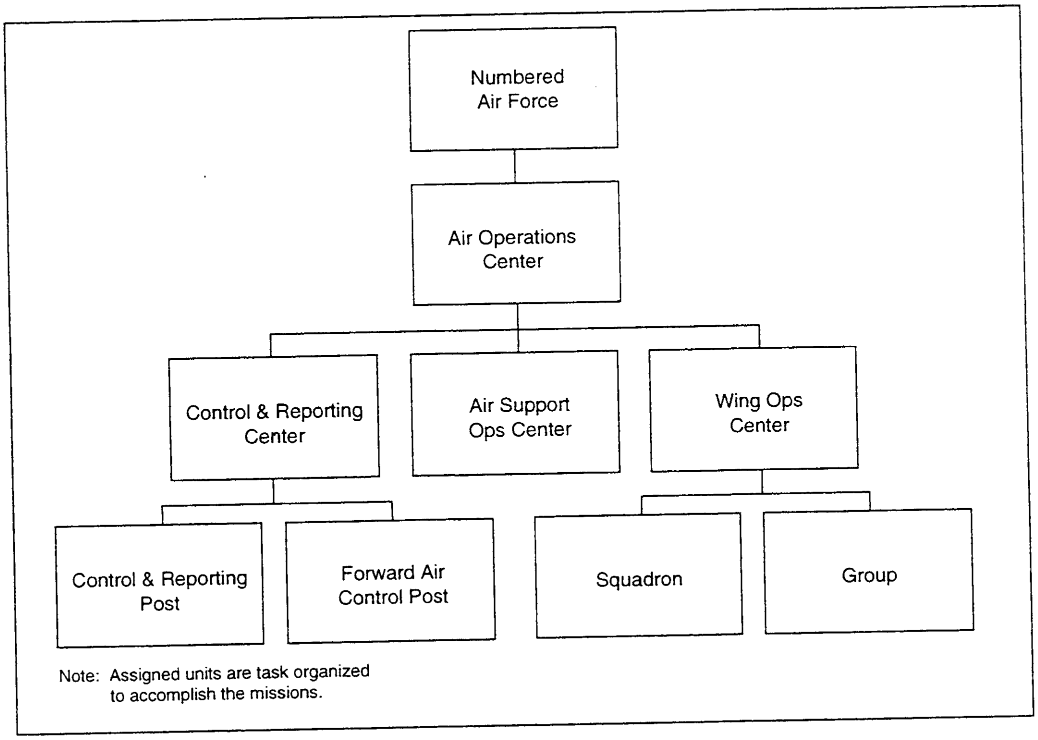

Figure 42. Air Force component Numbered Air Force class.

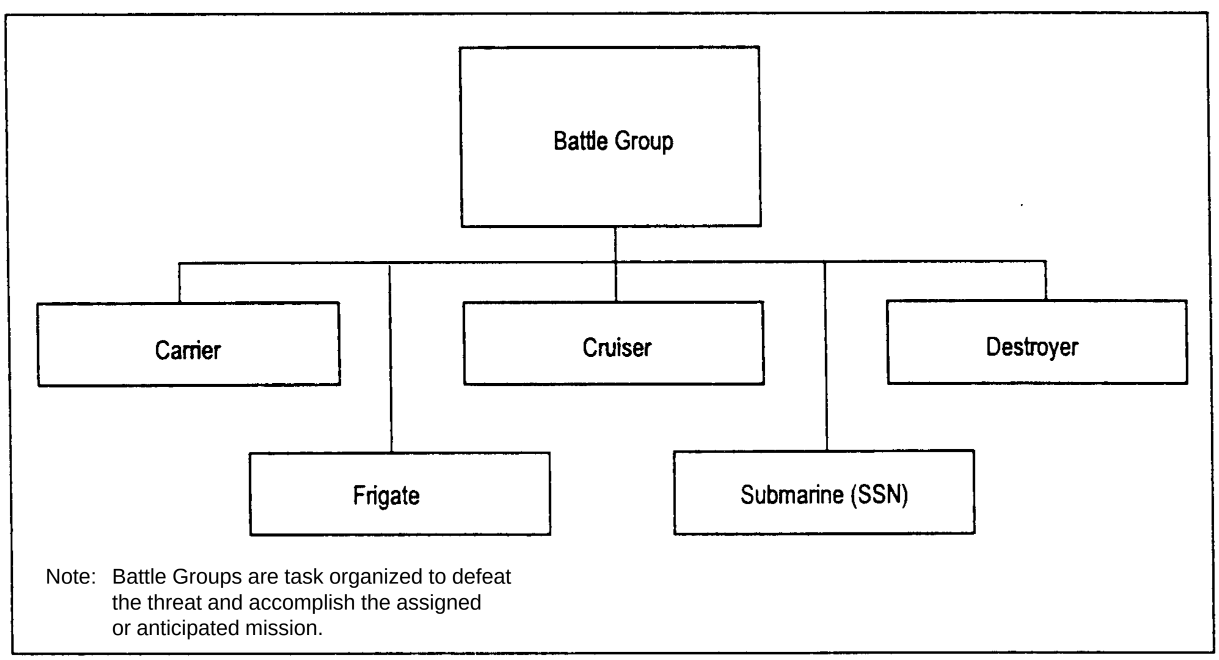

Figure 43. Navy Battle Group class.

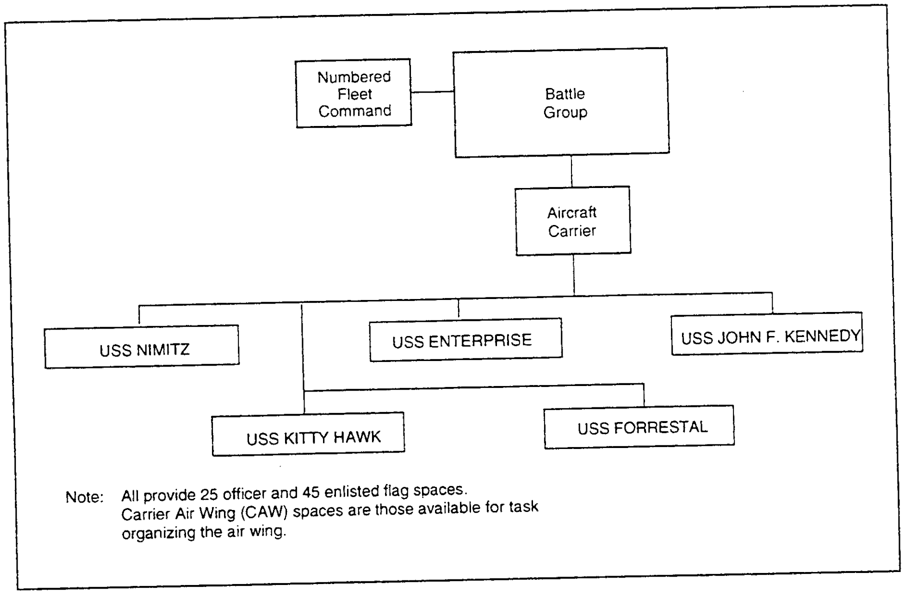

Figure 44. Navy Aircraft Carrier class.

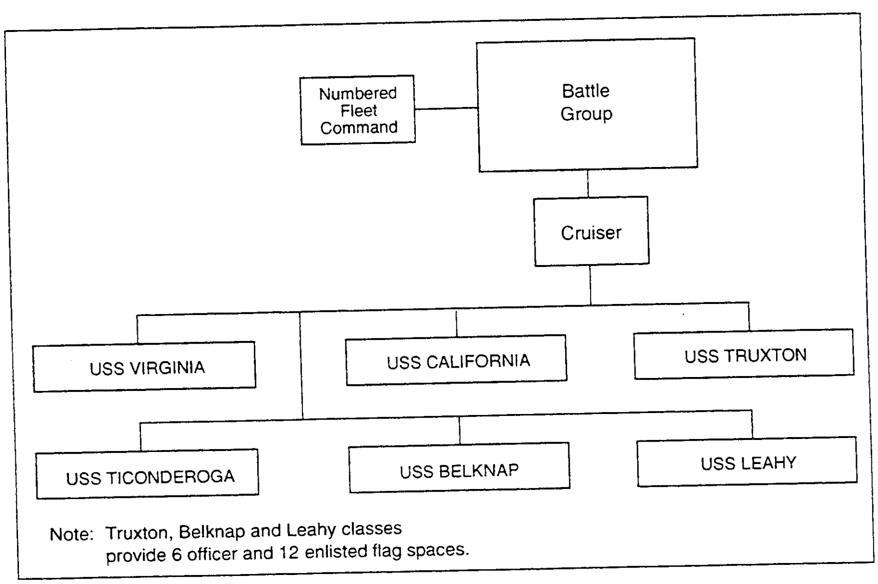

Figure 45. Navy Cruiser class.

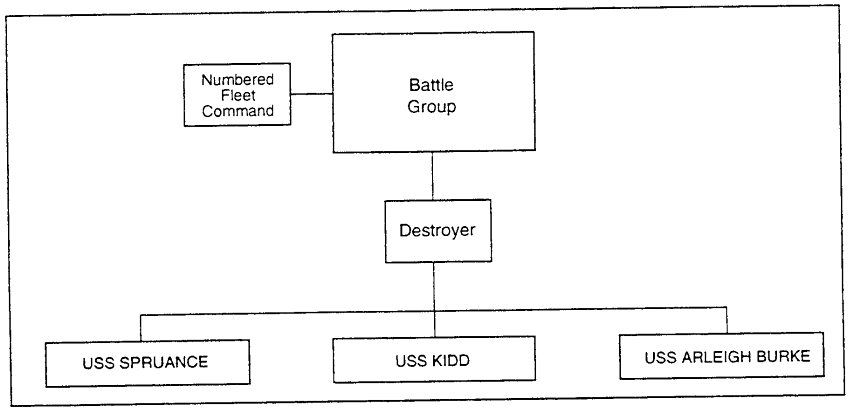

Figure 46. Navy Destroyer class.

The U.S. Frigate class has two subclasses: USS *Oliver Hazard Perry* and USS *Knox* (figure 47).

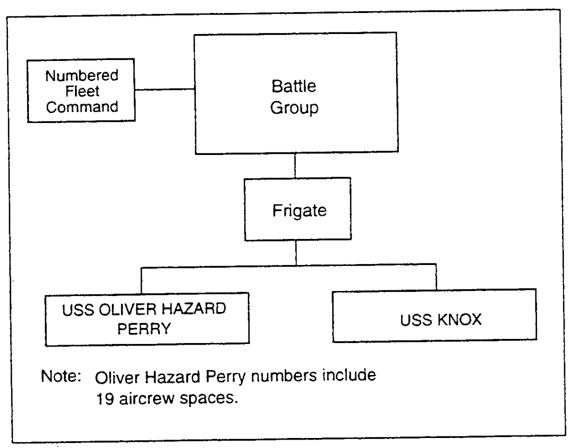

Figure 47. Navy Frigate class.

The U.S. Submarine class has four subclasses: one strategic mission class, USS *Ohio* (SSBN), and three attack classes, USS *Sturgeon* (SSN), USS *Seawolf* (SSN), and USS *Los Angeles* (SSN) (figure 48).

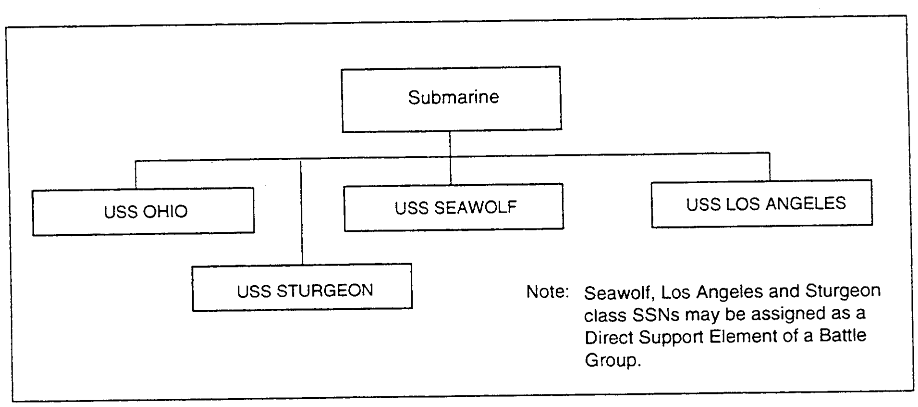

Figure 48. Navy Submarine class.

The Amphibious Group organization is composed of physical ships (vessels) organized to accomplish amphibious assault from the sea to land using both surface and air assault assets. The Amphibious Group includes Amphibious Assault Ship (LHD, LHA, LPH), Amphibious Command Ship (LCC), Amphibious Transport Dock Ship (LPD), Dock Landing Ship (LSD), and Tank Landing Ship (LST), as shown in figure 49.

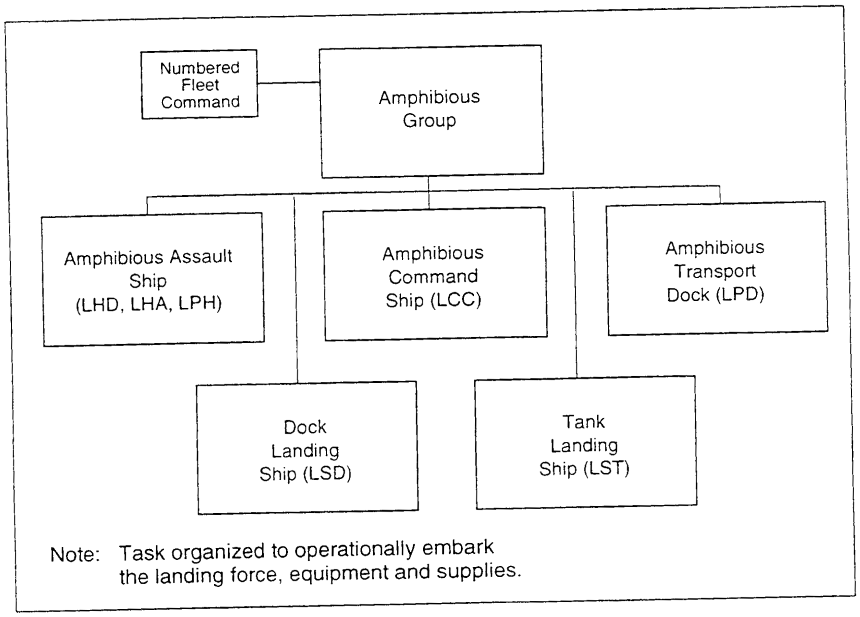

Figure 49. Navy Amphibious Group class.

The U.S. Amphibious Assault Ship class has three subclasses: USS *Wasp*, USS *Tarawa*, and USS *Iwo Jima*, as shown in figure 50.

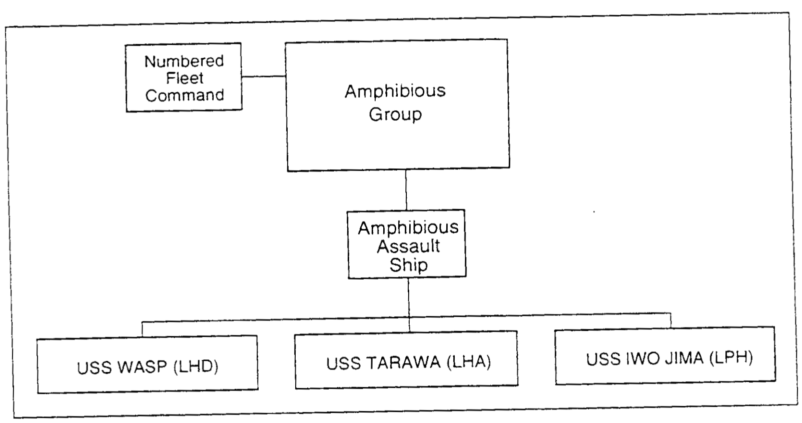

Figure 50. Navy Amphibious Assault Ship class.

The U.S. Amphibious Command Ship (LCC) class has one subclass, the USS *Blue Ridge* (figure 51).

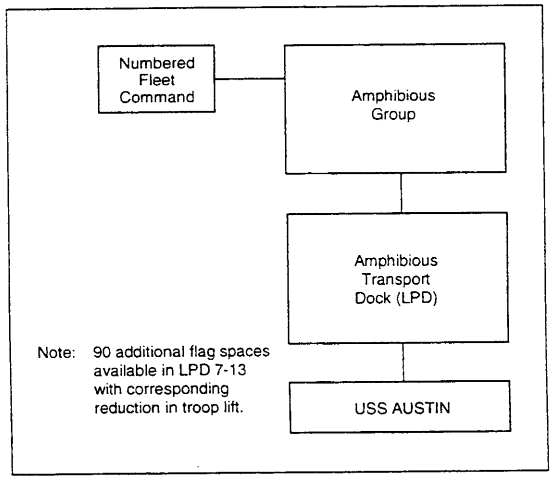

Figure 51. Navy Amphibious Command Ship class.

The U.S. Amphibious Transport Dock class has one subclass, the USS *Austin* (figure 52).

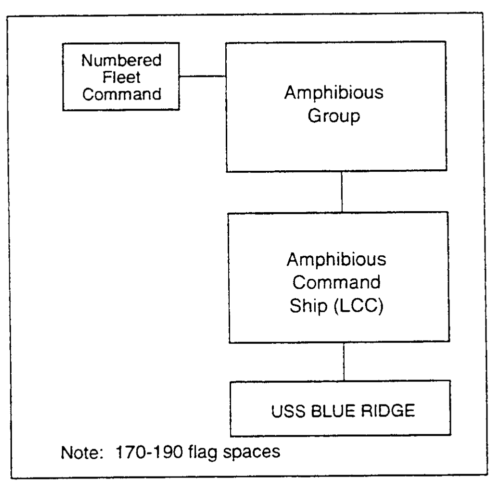

Figure 52. Navy Amphibious Transport Dock class.

The U.S. Dock Landing Ship (LSD) class has three subclasses: USS *Whidbey Island*, USS *Harper Ferry*, and USS *Anchorage* (figure 53).

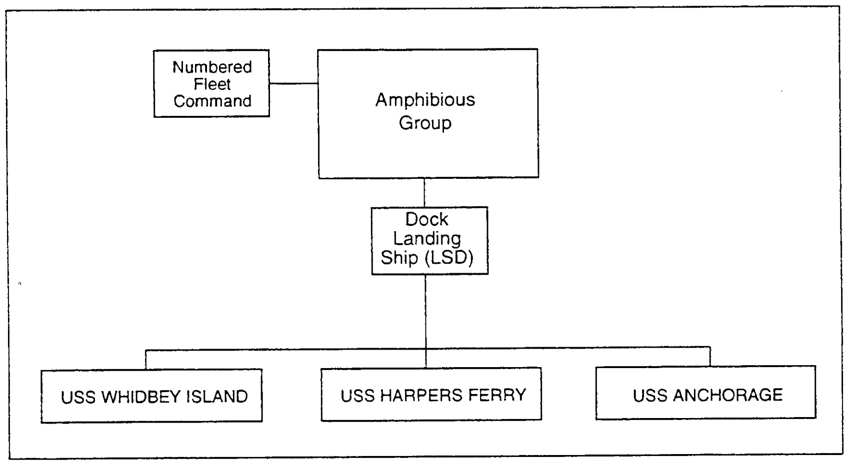

Figure 53. Navy Dock Landing Ship class.

The U.S. Tank Landing Ship (LST) class has one subclass, the USS *Newport* (figure 54).

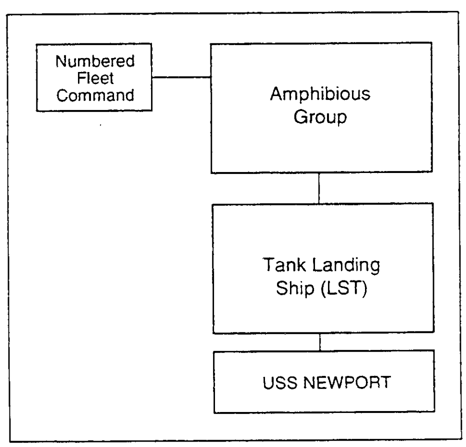

Figure 54. Navy Tank Landing Ship class.

The Replenishment Group organization consists of physical ships (vessels) organized to replenish other U.S. naval vessels both at sea or in port using at-sea replenishment techniques, alongside replenishment, and/or helicopter replenishment, depending on product required. The Replenishment

Group class has five subclasses: Ammunition Ship (AE), Combat Stores Ship (AOE), Oiler (AO), Fast Combat Support Ship (AFS), and Replenishment Oiler (AOR), as shown in figure 55.

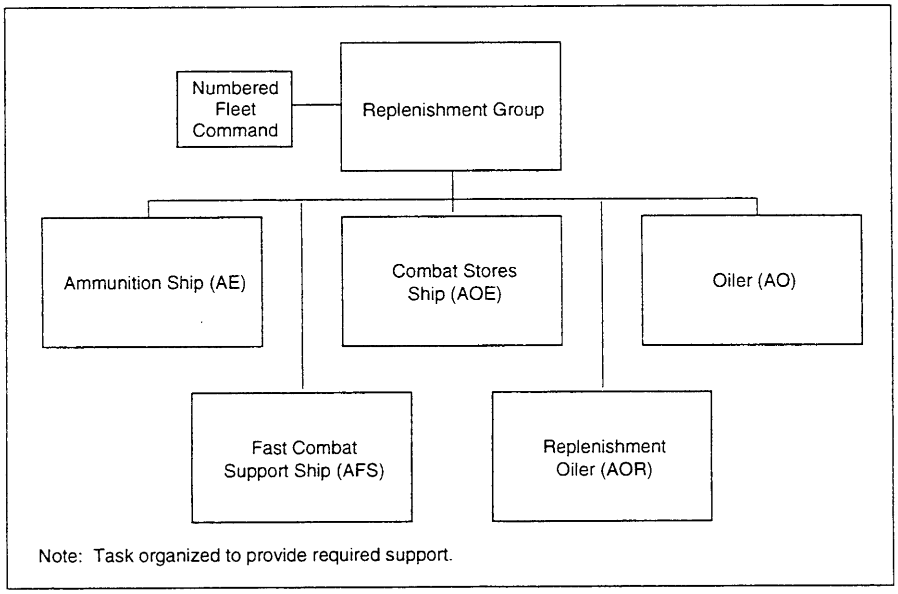

Figure 55. Navy Replenishment Group class.

The U.S. Marine Corps component is organized as a Marine Expeditionary Force composed of ground, aviation, and service support elements that constitute a single weapons system—the Marine Air-Ground Task Force (figure 56).

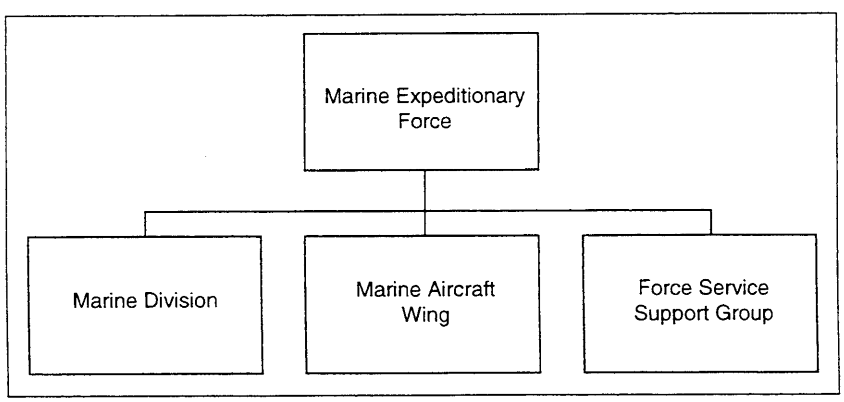

Figure 56. Marine Expeditionary Force superclass.

The U.S. Marine Division is task organized to execute amphibious assault operations and such other operations as may be directed, supported by Marine aviation, force service support units, and other supporting units (figure 57).

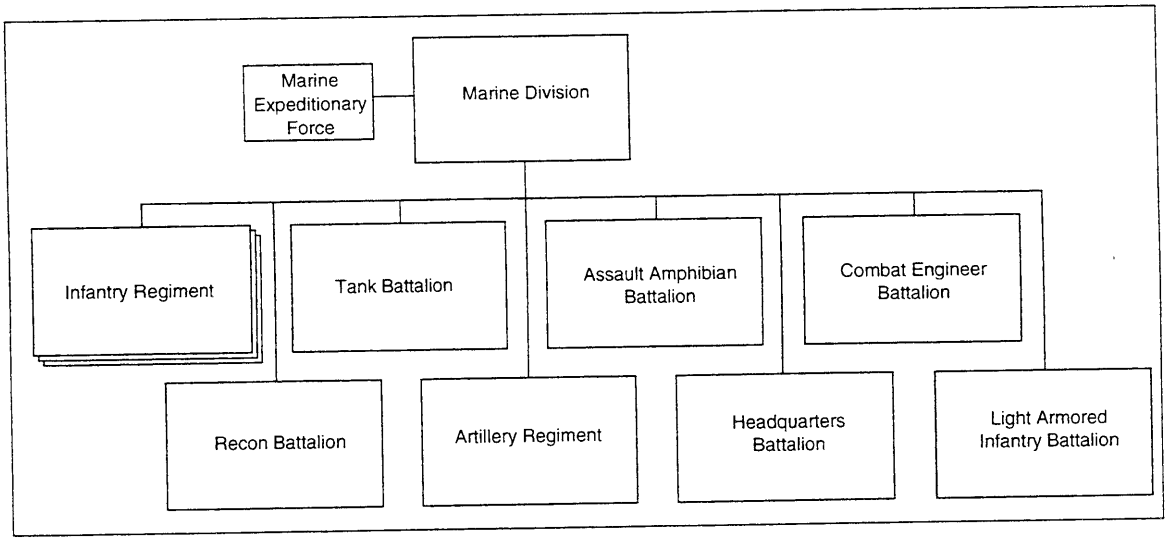

Figure 57. Marine Division class.

The U.S. Marine Infantry Regiment is the major element of close combat power of the Marine division (figure 58).

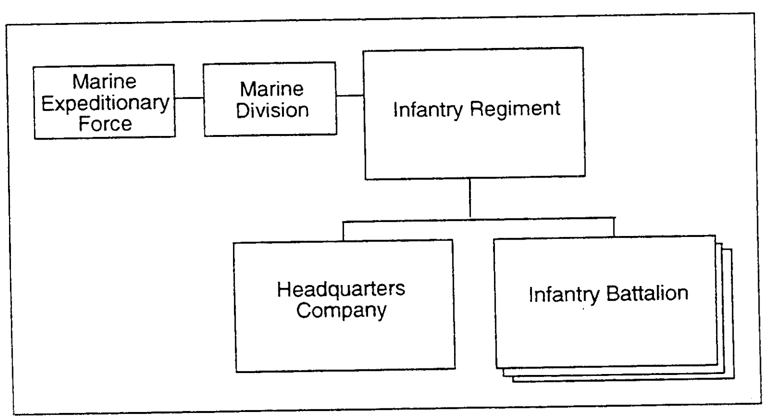

Figure 58. Marine Infantry Regiment class.

The U.S. Marine Aircraft Wing is task organized to participate as the supporting air component of a Marine Expeditionary Force or as an integral part of navy aviation (figure 59).

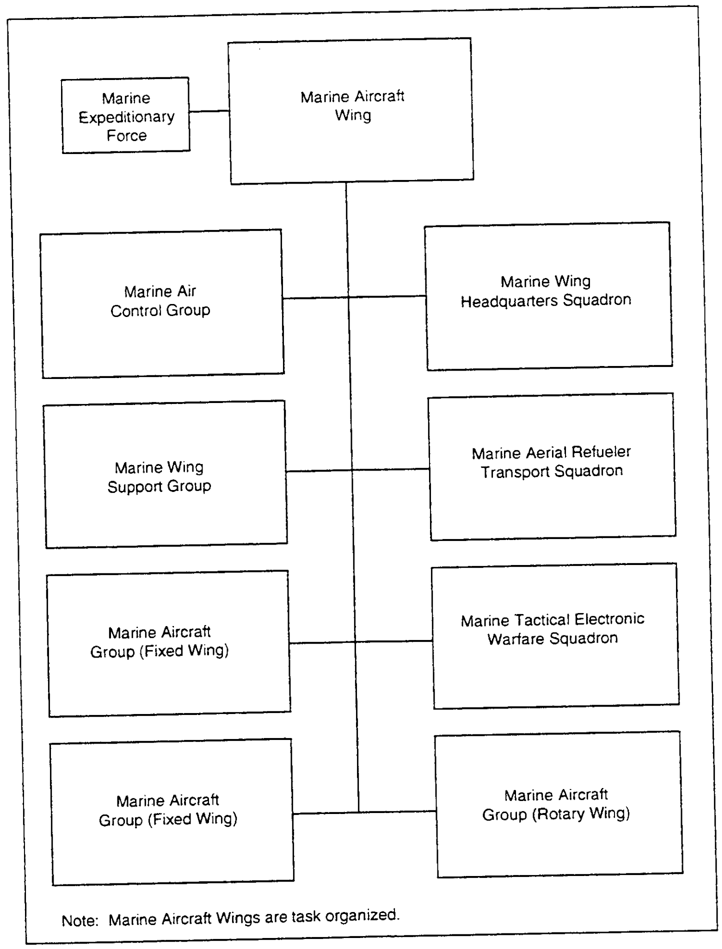

Figure 59. Marine Aircraft Wing class.

The U.S. Marine Aircraft Group (Fixed Wing) is organized to conduct offensive air support and air interdiction from land force or carrier (figure 60).

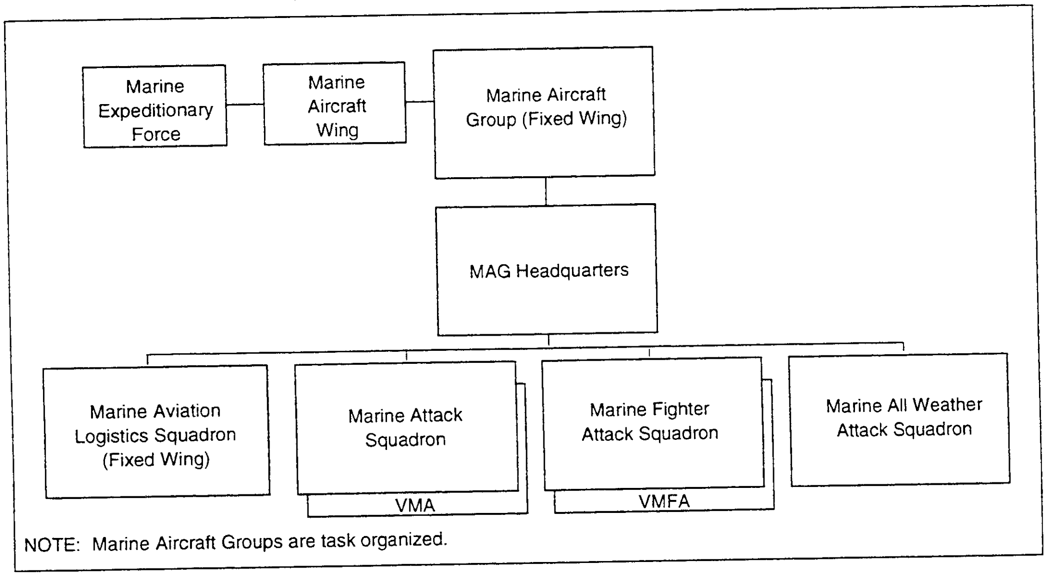

Figure 60. Marine Aircraft Group (Fixed Wing) class.

The U.S. Marine Aircraft Group (Rotary Wing) provides assault support for all Marine units (figure 61).

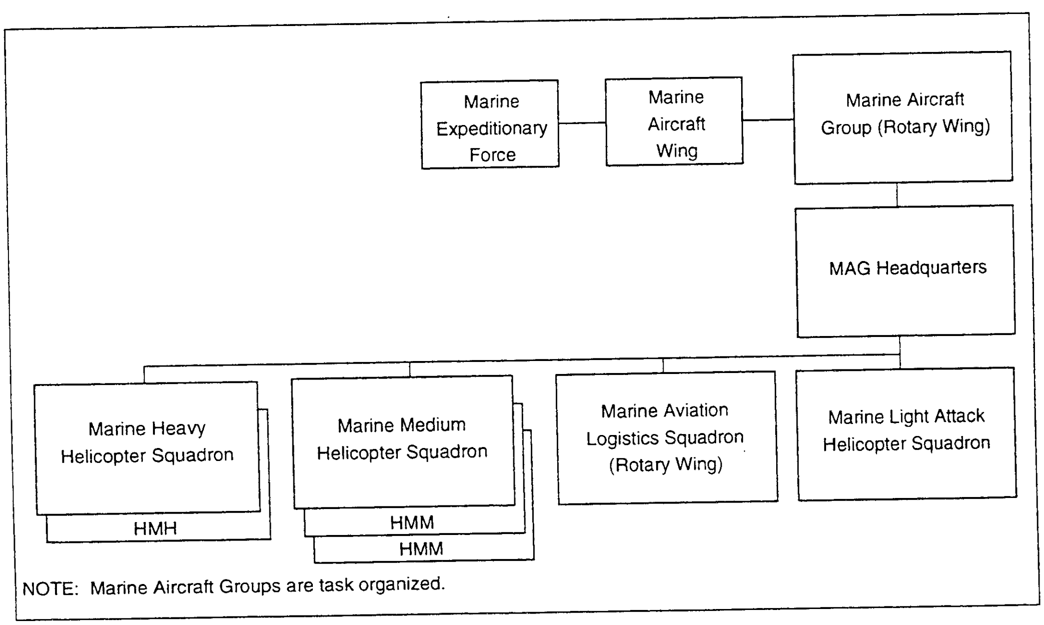

Figure 61. Marine Aircraft Group (Rotary Wing) class.

The U.S. Marine Corps Force Service Support Group is a composite grouping of functional components that provides support above the organic capability of the supported Marine units (figure 62).

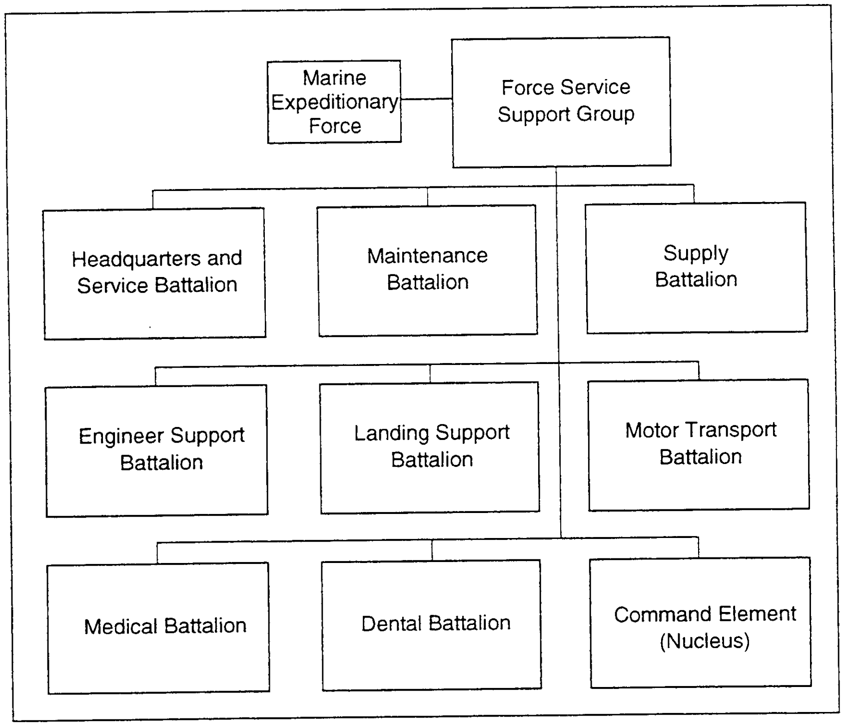

Figure 62. Marine Force Service Support Group.

7.5 COMMAND AND CONTROL SUBTREE

The Command and Control association class is the relationship that gives Agent, Event, and Physical definition and place in the real world (figure 63). The principal attributes of the Command and Control association class are Information Products, which include objects such as Plan, Order, Report, Message, E-Mail, Memo, Letter, Standard Operating Procedure (SOP), Rules of Engagement (ROE), Estimate, Objective, Goal, Course of Action, Mission Statement, and Task Statement.

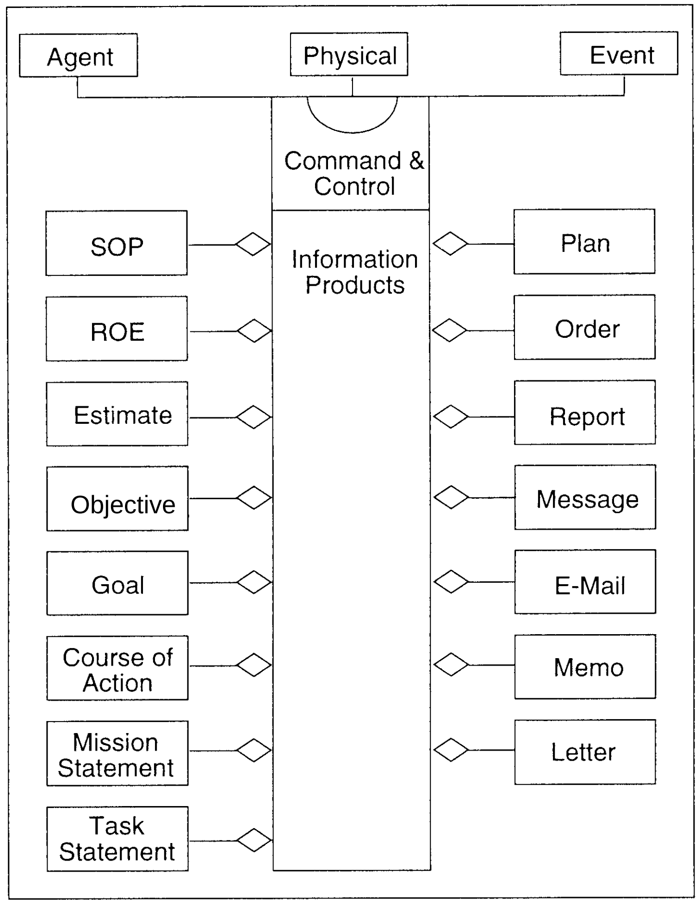

Figure 63. Command and Control association class.

8. PLANS

This section discusses current, near-term, long-term, and very long-term plans for JWSOL.

8.1 CURRENT TASKING

There are three remaining tasks:

1. *Solicit, analyze, and incorporate comments*. This document will be circulated, comments solicited, and changes incorporated into the taxonomy according to the nature and quality of the response received.
2. *Expand class specifications*. Expand the taxonomy and its contents. The methods named in the current representation will be further detailed by specifying their input and output forms and value ranges. State diagrams will be created to represent changes of state for key classes. Martin/Odell event flows will also be created to represent typical envisioned mission and process flows.
3. *Unify, validate, and publish*. All of the material developed for and received in response to the project will be reviewed. Recommended changes will be made to the taxonomy and to this document. A Joint Warfare Taxonomy document, companion to the JWSOL Requirements, will be published.

8.2 NEAR-TERM OBJECTIVES

There are four near-term objectives:

1. *Complete detailed design; complete specification of objects*. During the second phase of the JWSOL project, object specifications for the warfare objects defined in the first phase will be developed. These specifications will be captured in an object model developed and documented with object-oriented design (OOD) Rumbaugh software. The construction of the object specifications will be an iterative process of prototyping and documenting. Iterations will continue until the entire set of objects, with their related inheritance hierarchies and "part-of" hierarchies, merge in a final design. That design will be documented iteratively and coded from the specifications. The SMEs will continue to support evaluation during the development of the object specifications.
2. *Monitor and incorporate evolving commercial and governmental standards*. Progress of commercial standards, such as CORBA, will be monitored. Standards will be reviewed and incorporated throughout the design and development of JWSOL objects to ensure compatibility with commercial object-oriented (OO) products.
3. *Continue relationships with collaborative programs*. Coordination with collaborative programs will continue. Relationships have been established with the JTF–ATD, OMWG, NSS, JSIMS, DEEM, and JWID-95 programs. Continued participation by JWSOL personnel in working groups associated with these programs will provide the necessary feedback to ensure the success of JWSOL.
4. *Build prototypes, deliver to programs, and perform beta test analysis*. The third phase of JWSOL will complete the prototype integration of COTS and GOTS features and concentrate on the test and evaluation of the library features. Operator and user documentation will be delivered. The library will be filled with validated objects and the first deployments will be made. At the end of this phase, the JWSOL capability will transition to life-cycle maintenance.

8.3 LONG-TERM OBJECTIVES

There are six long-term objectives:

1. *Extend JWSOL to other warfare and operations other than war areas*. A natural customer-driven extension of JWSOL is to more levels of operations and more kinds of operations. The structure of the taxonomy is very friendly to such extension, which, in the long run, might result in the merging of JWSOL with other taxonomic efforts.
2. *Extend JWSOL to multiple levels of resolution*. Multiple resolution is a difficult ongoing problem for M&S. Possibly using the notion of perspectives, JWSOL will be refined to offer multiple levels of resolution on demand. This would apply to multiple interfaces, multiple attributes, and multiple methods, satisfying the levels of resolution necessary, as defined by customer demand.
3. *Integrate knowledge systems technology into JWSOL*. Several available public-domain knowledge system tools might be integrated into JWSOL—CLIPS, KRSL, and KADS are three examples. Also, knowledge visualization efforts are going on in many places in the military—the Navy Underwater Warfare Center and Rome Laboratory are two reserach sites. Knowledge systems tools and knowledge visualization capabilities would be integrated to facilitate explicit, user-modifiable strategy and tactics modeling as well as deeper representation of command and control decision making.
4. *Build sample models and applications*. Sample model components, models, and applications will be built using JWSOL classes and objects. These are a valuable aid to programmers new to JWSOL by providing a guide to model construction. Use of sample programs is standard in commercial software tool publishing.
5. *Interact to provide possible cross-over with JTF–ATD OMWG C^2 Schema*. The OMWG C^2 Schema, discussed in section 3.4, has been closely coordinated with the development of the JWSOL taxonomy. That effort will evolve, based on its customer's needs and the rate at which it is fielded. JWSOL covers areas that the OMWG is not intended to support, but for common ground, the potential exists for productive interaction. Design and implementation elements from OMWG will be incorporated where necessary to better support JWSOL users.
6. *Integrate validated classes and objects into an Information Analysis Center.* Development, implementation, documentation, configuration management, VV&A, and support activities will be performed to make the JWSOL repository suitable for incorporation into an Information Analysis Center (IAC).

8.4 VERY LONG-TERM OBJECTIVES

Extending JWSOL to the ultra-fine-grained acqusition model level is a very long-term objective. ARPA is funding smart product model research, which extends modeling and simulation down to the CAD/CAM level, and proposed 200-gigabyte models.

9. REFERENCES

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APPENDIX A: JWSOL ATTRIBUTES AND METHODS

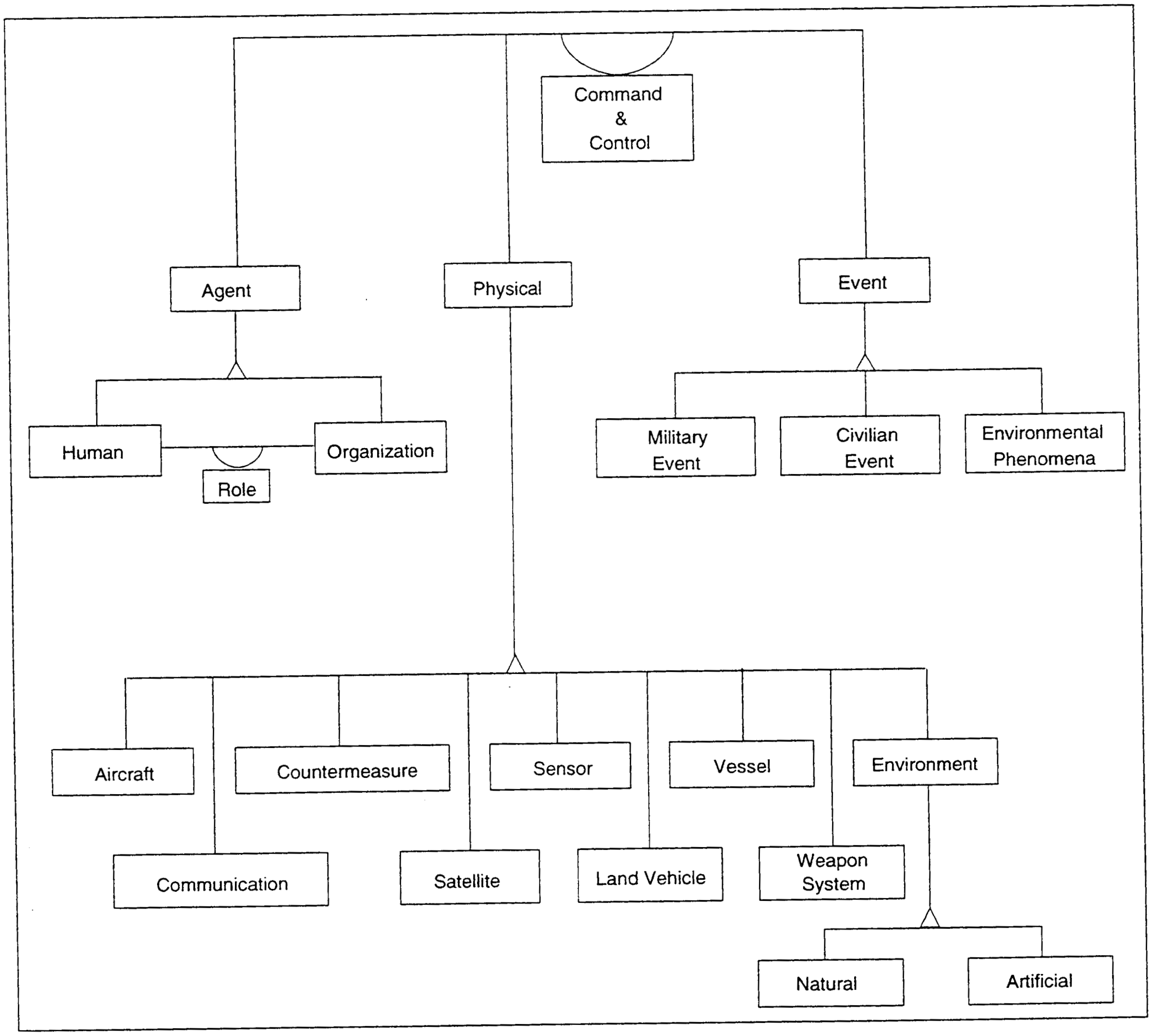


Figure A-1. Agent, physical and event classes, with a command and control association.

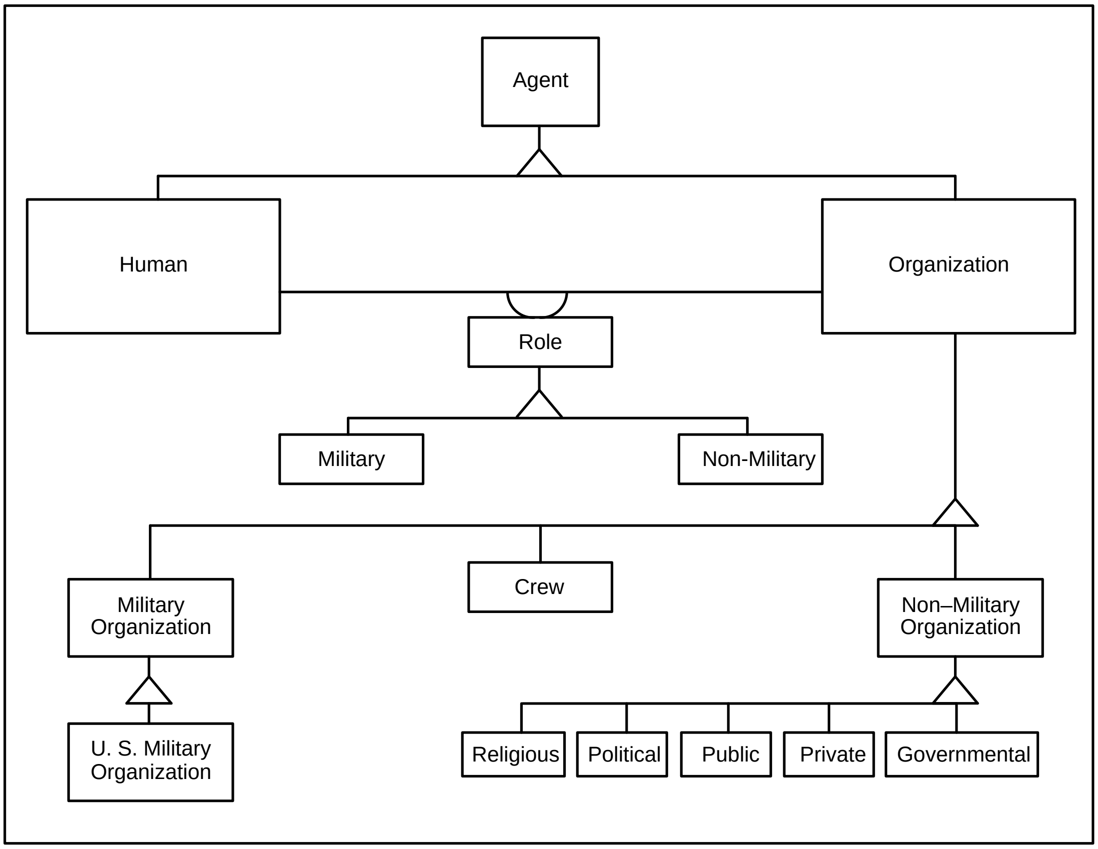


Figure A-2. Agent subtree.

Agent
Goal Plan Concept Habit Foible Judgement Imagined Future

Figure A-3a. Agent attributes.

Agent
Develop Goal Develop Concept

Figure A-3b. Agent methods.

Human
Profession Skill Degree Of Proficiency Sex Age Language(S) Special Physical Characteristics

Figure A-4a. Human attributes.

Human
Objects of this class will specialize inherited methods.

Figure A-4b. Human methods.

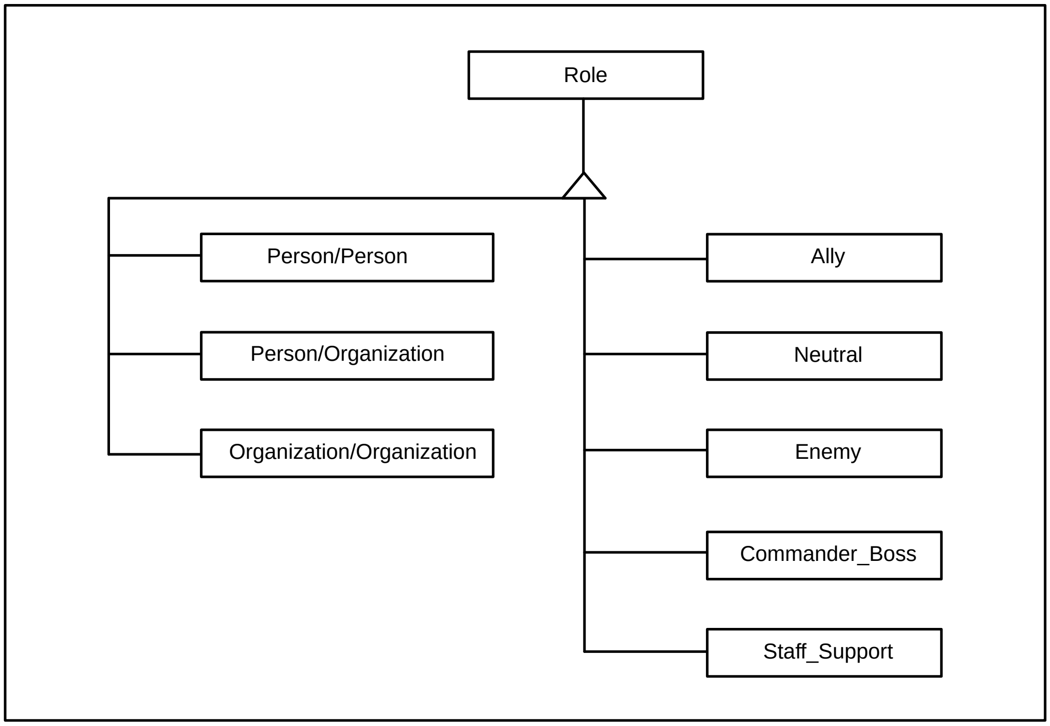


Figure A-5. Role association chart.

Role
Autonomy Authority Responsibility Obligation Title Seniority Name Of Role

Figure A-6a. Role association attributes.

Role
Objects of this class will specialize inherited methods.

Figure A-6b. Role association methods.

Person/Person
Reciprocal (y/n) Mirror (y/n)

Figure A-6c. Person/ person attributes.

Person/Person
Objects of this class will specialize inherited methods.

Figure A-6d. Person/ person methods.

Person/Organization
Mirror (y/n) Title Seniority

Figure A-6e. Person/ organization attributes.

Person/Organization
Objects of this class will specialize inherited methods.

Figure A-6f. Person/ organization methods.

Organization/Organization
Reciprocal (y/n) Name

Figure A-6g. Organization/ organization attributes.

Organization/Organization
Objects of this class will specialize inherited methods.

Figure A-6h. Organization/ organization attributes.

Ally
Bounds Context (event)

Figure A-6i. Ally attributes.

Ally
Objects of this class will specialize inherited methods.

Figure A-6j. Ally methods.

Neutral
WRT (event) Constraints

Figure A-6k. Neutral attributes.

Neutral
Develop Doctrine

Figure A-6l. Neutral methods.

Enemy
Category (military, economic, political) Status (war, negotiation, peace)

Figure A-6m. Enemy attributes.

Enemy
Declare War Negotiate

Figure A-6n. Enemy methods.

Organization
Purpose Structure Authority Capabilities Country_name Location

Figure A-7a. Organization attributes.

Organization
Establish Goals

Figure A-7b. Organization methods.

Military
Rank MOS NEC Subspecialty Code

Figure A-8a. Military attributes.

Military
Assign Rank Form Units

Figure A-8b. Military methods.

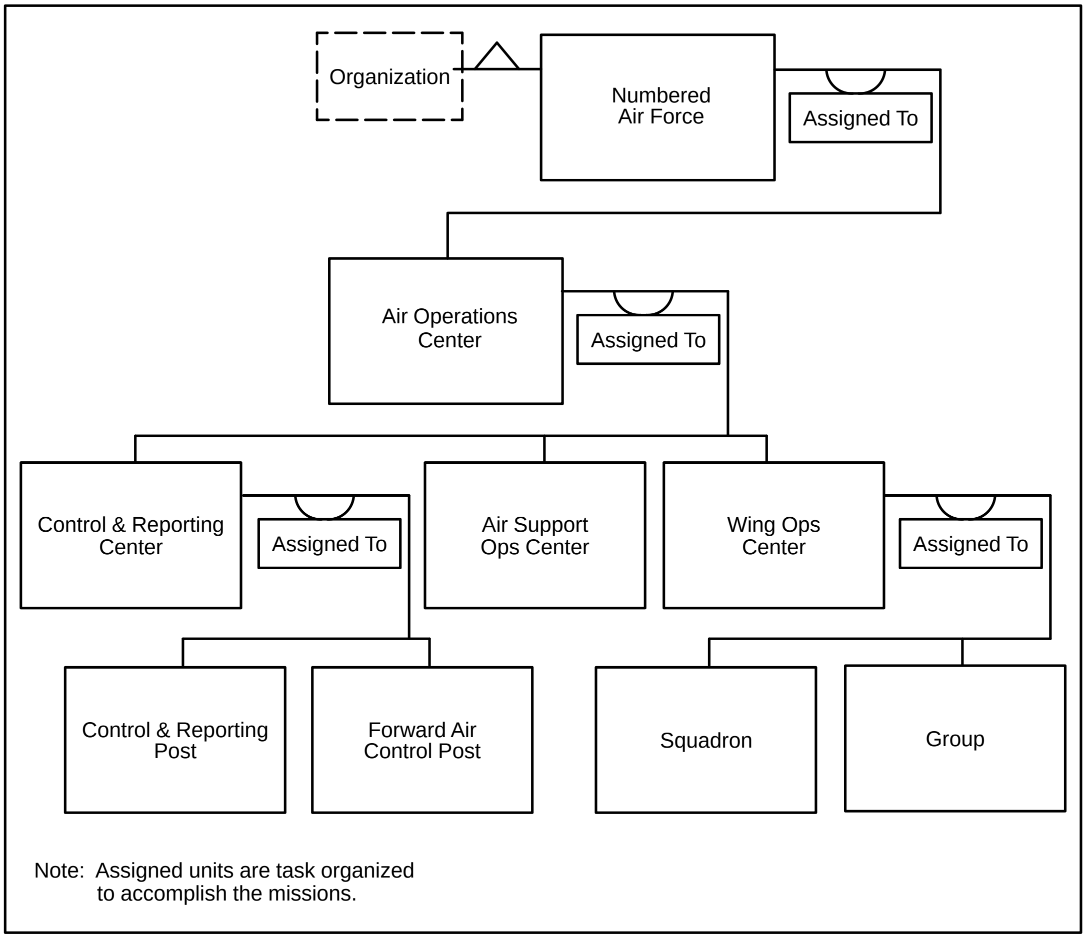


Figure A-9. Air Force component numbered Air Force class.

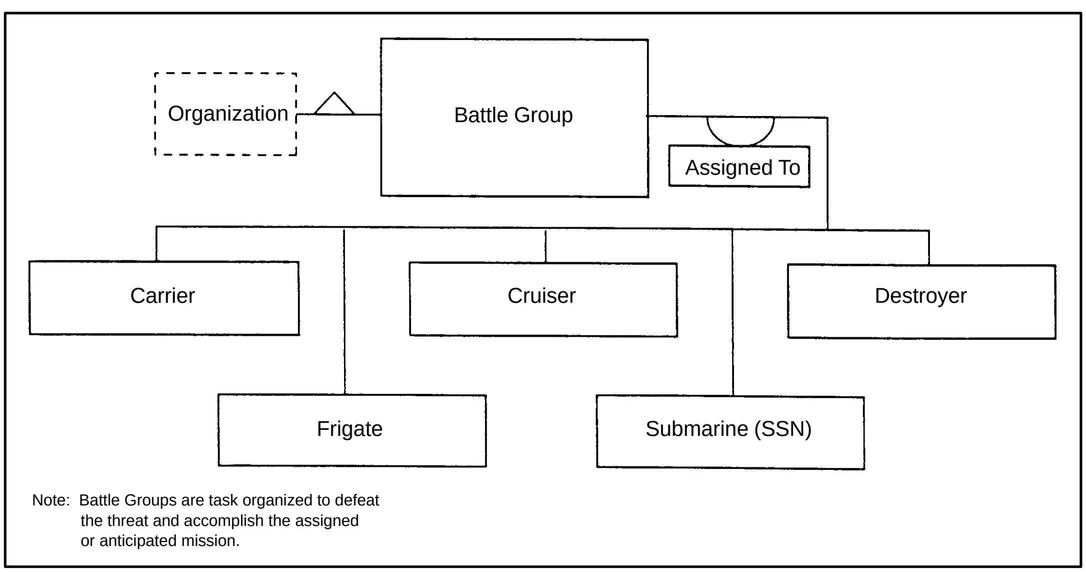


Figure A-10. Navy battle group class.

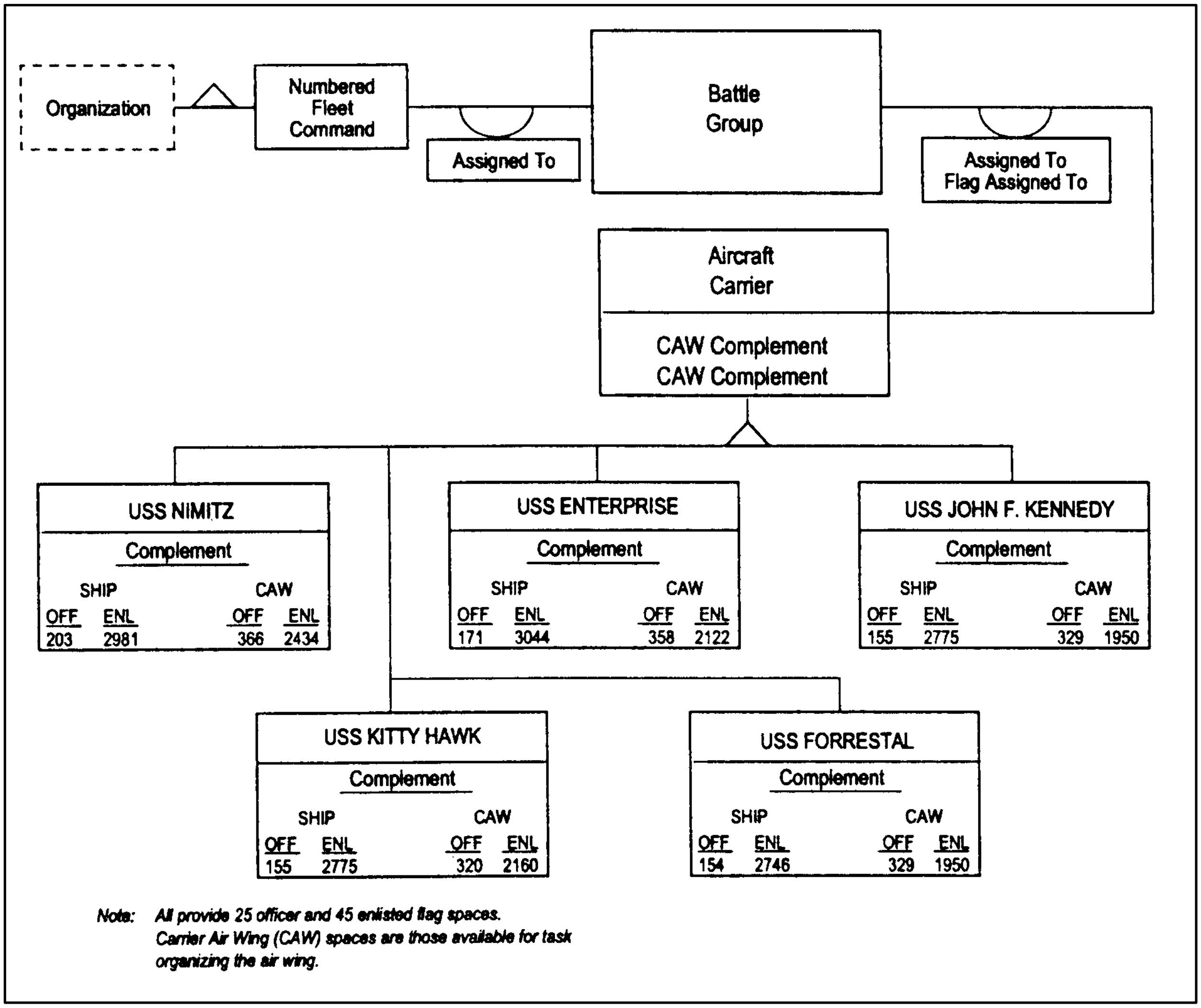


Figure A-11. Navy aircraft carrier class.

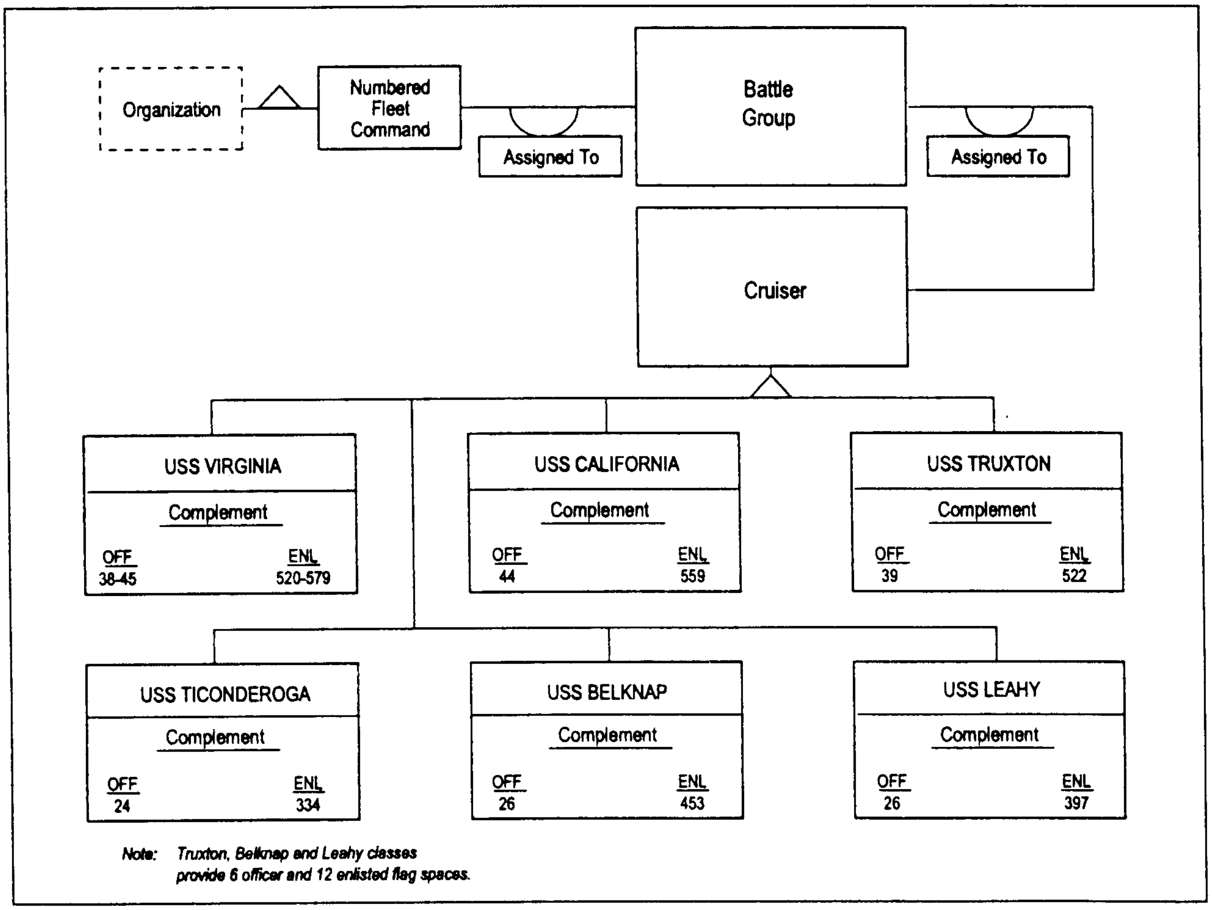


Figure A-12. Navy cruiser class.

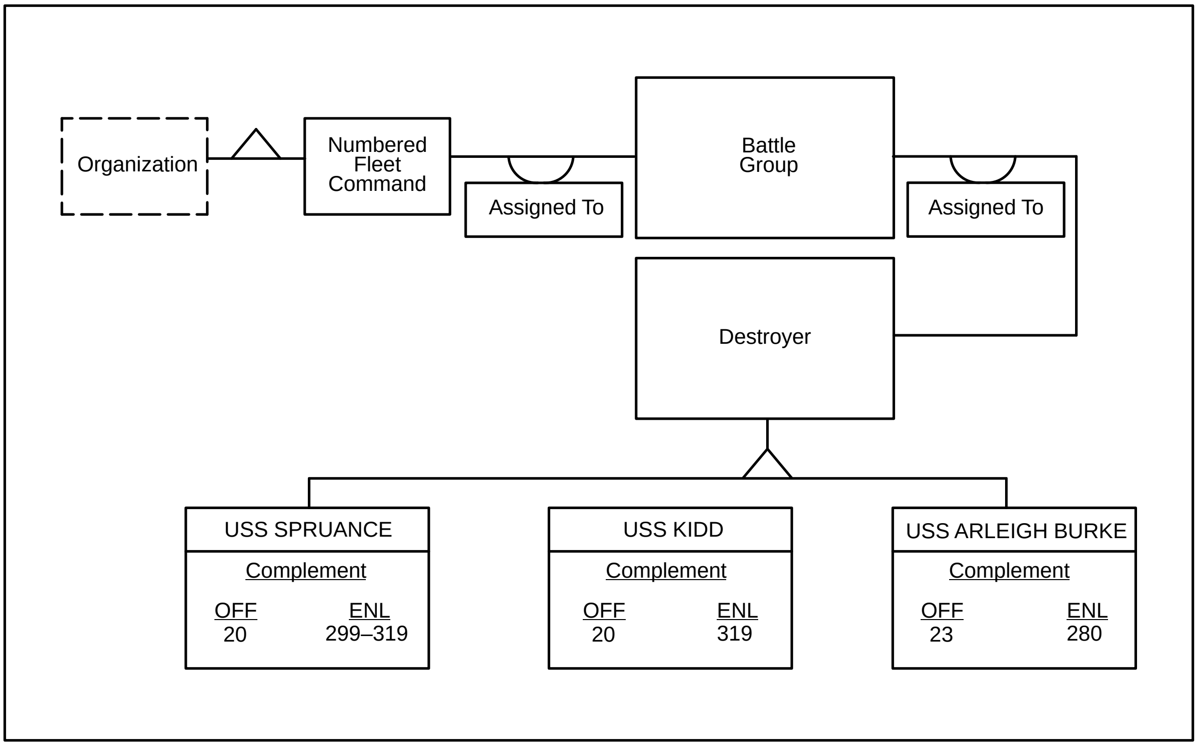


Figure A-13. Navy destroyer class.

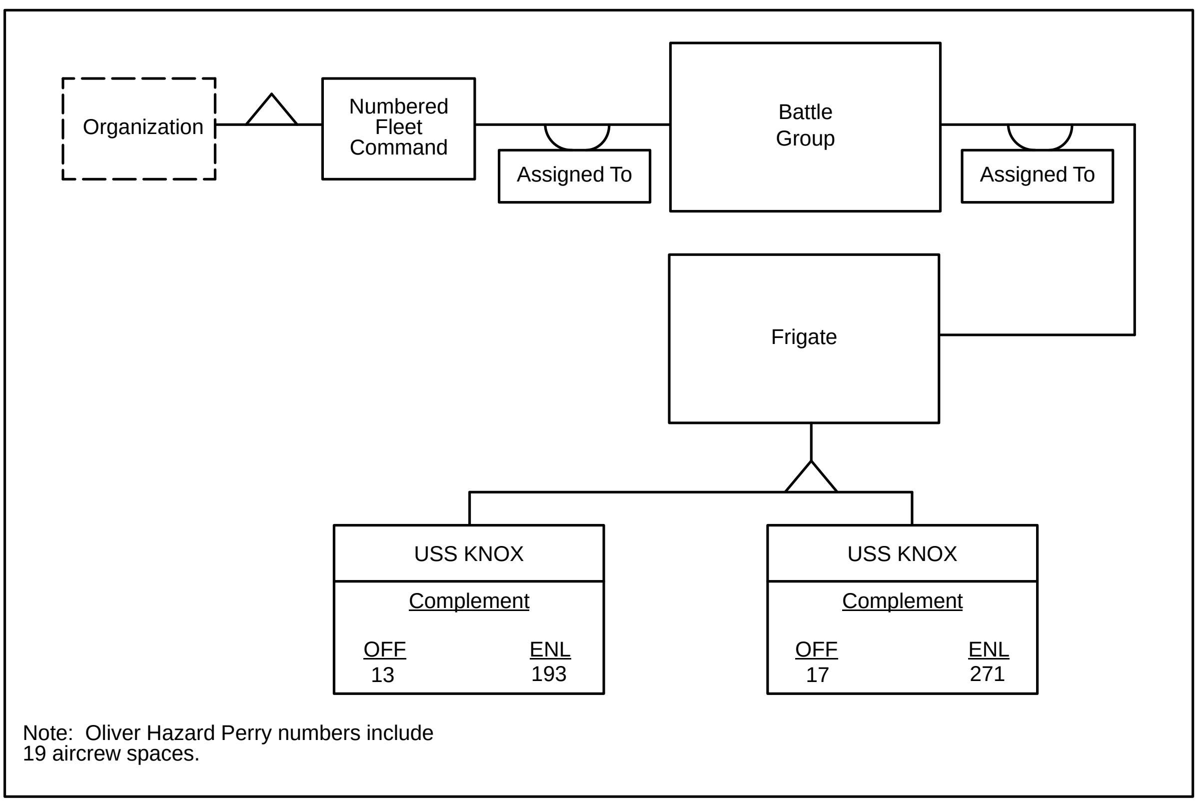


Figure A-14. Navy frigate class.

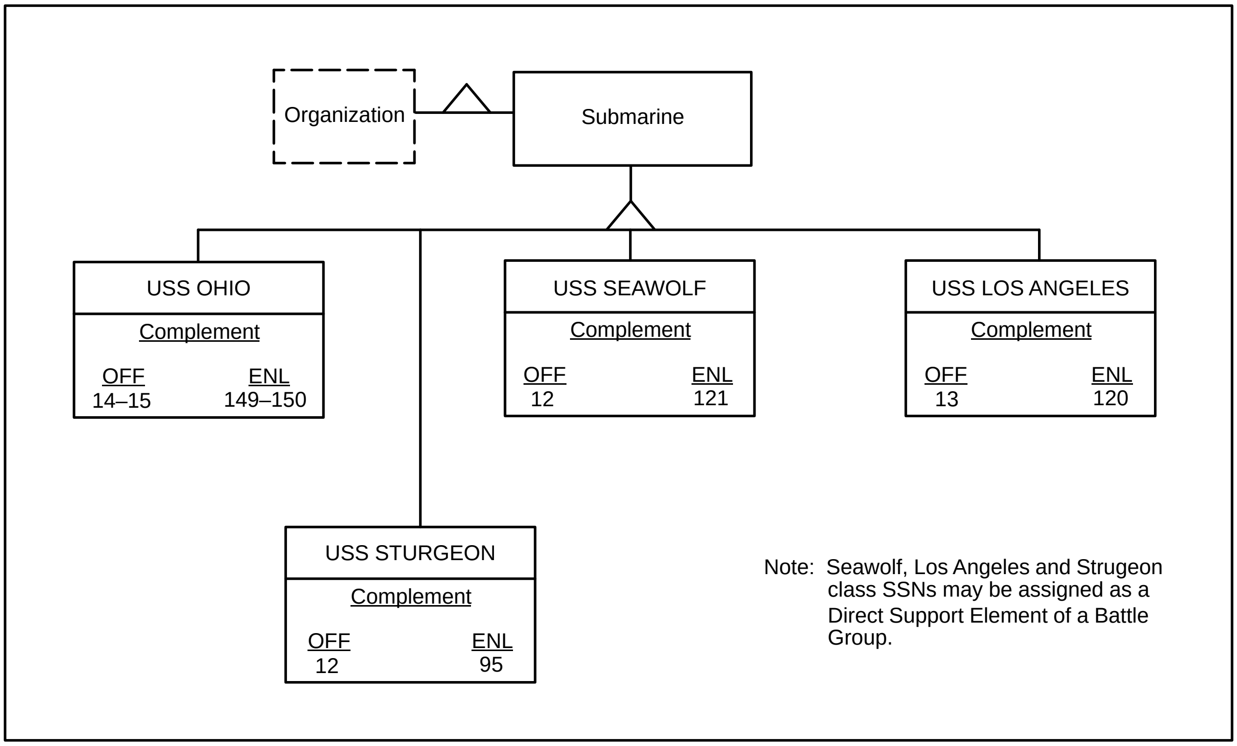


Figure A-15. Navy submarine class.

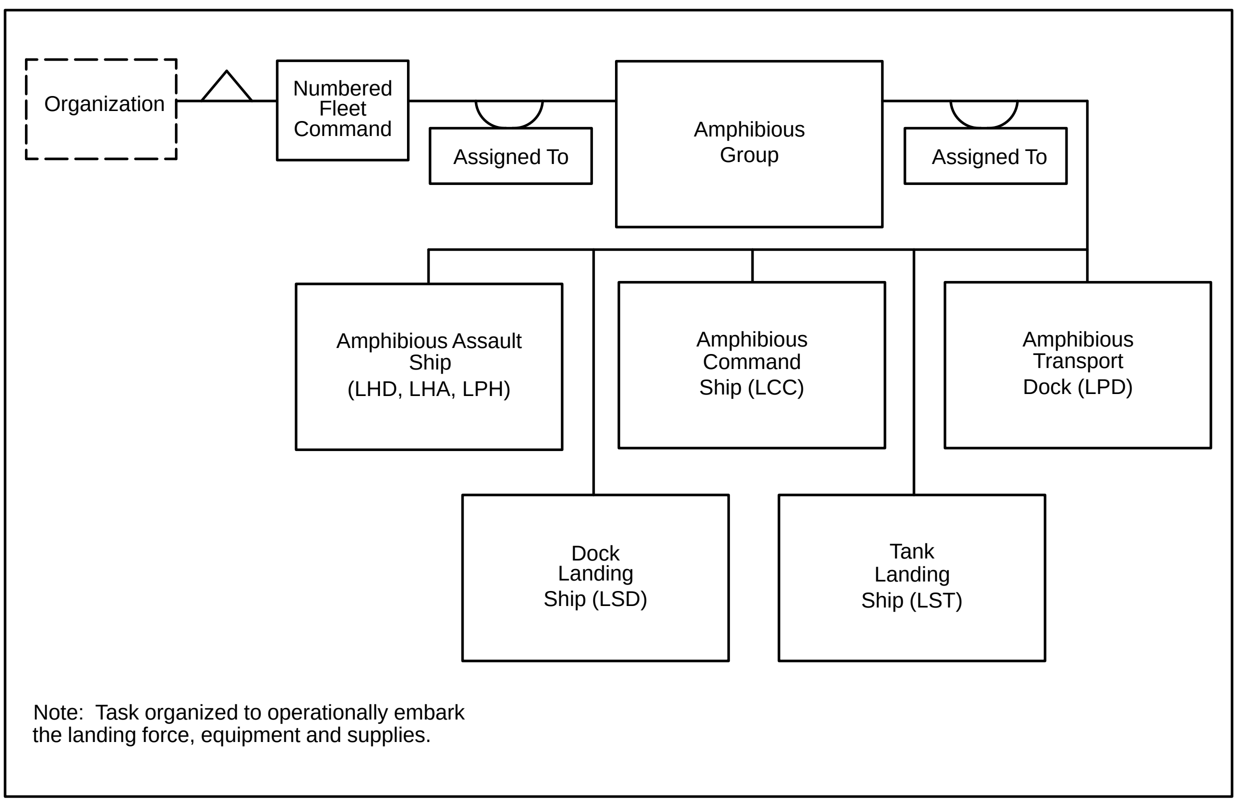


Figure A-16. Navy amphibious group class.

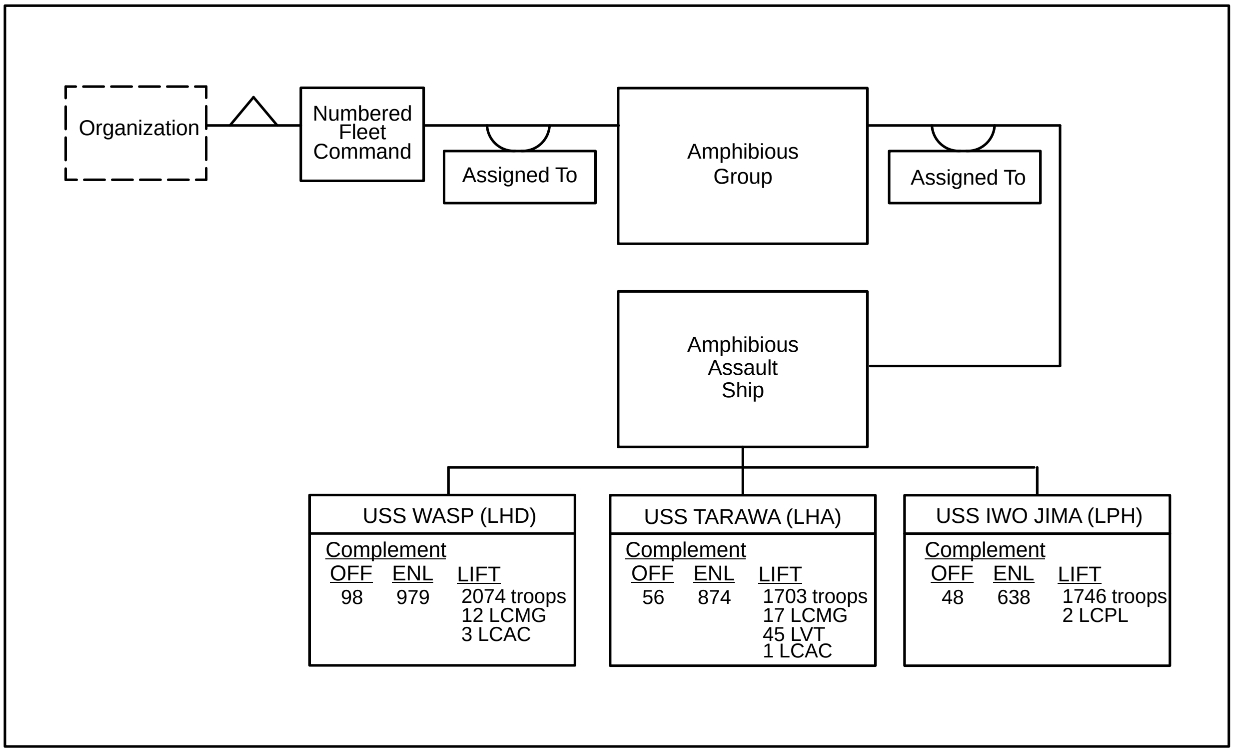


Figure A-17. Navy amphibious assault ship classes.

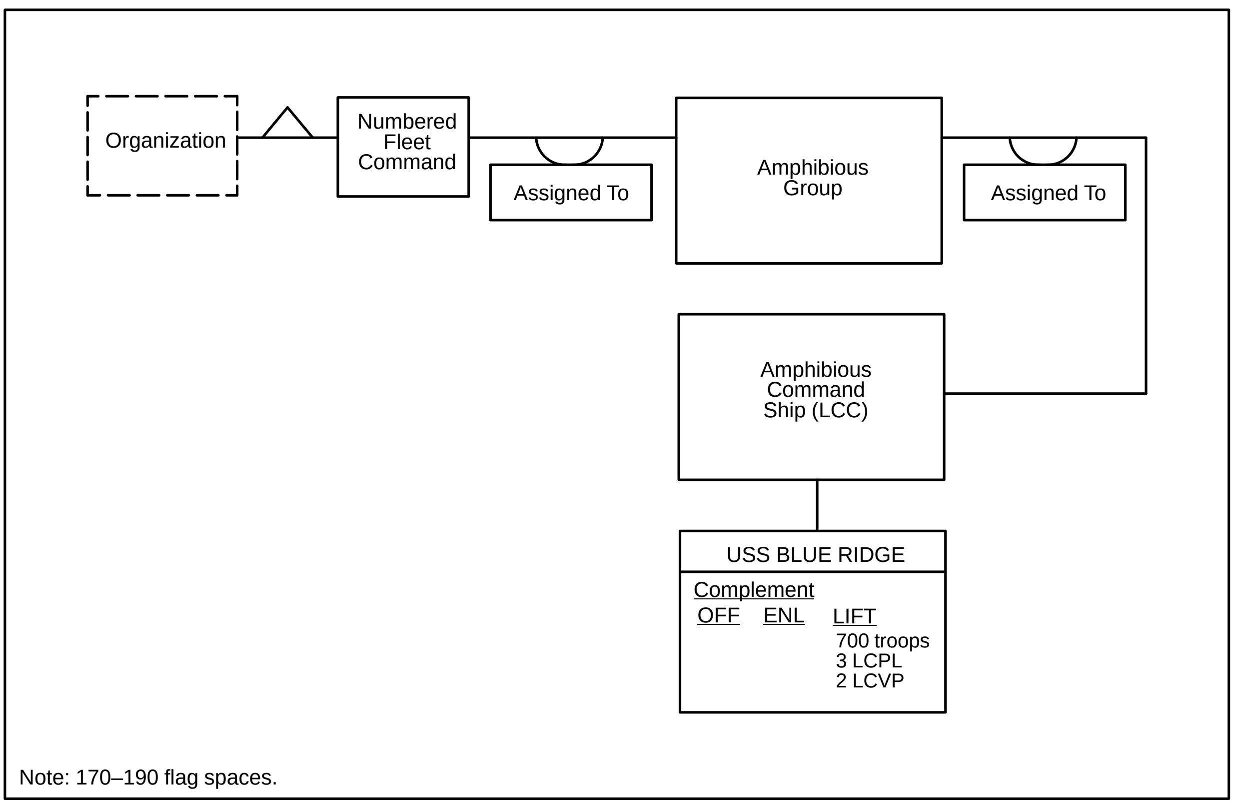


Figure A-18. Navy amphibious command ship class.

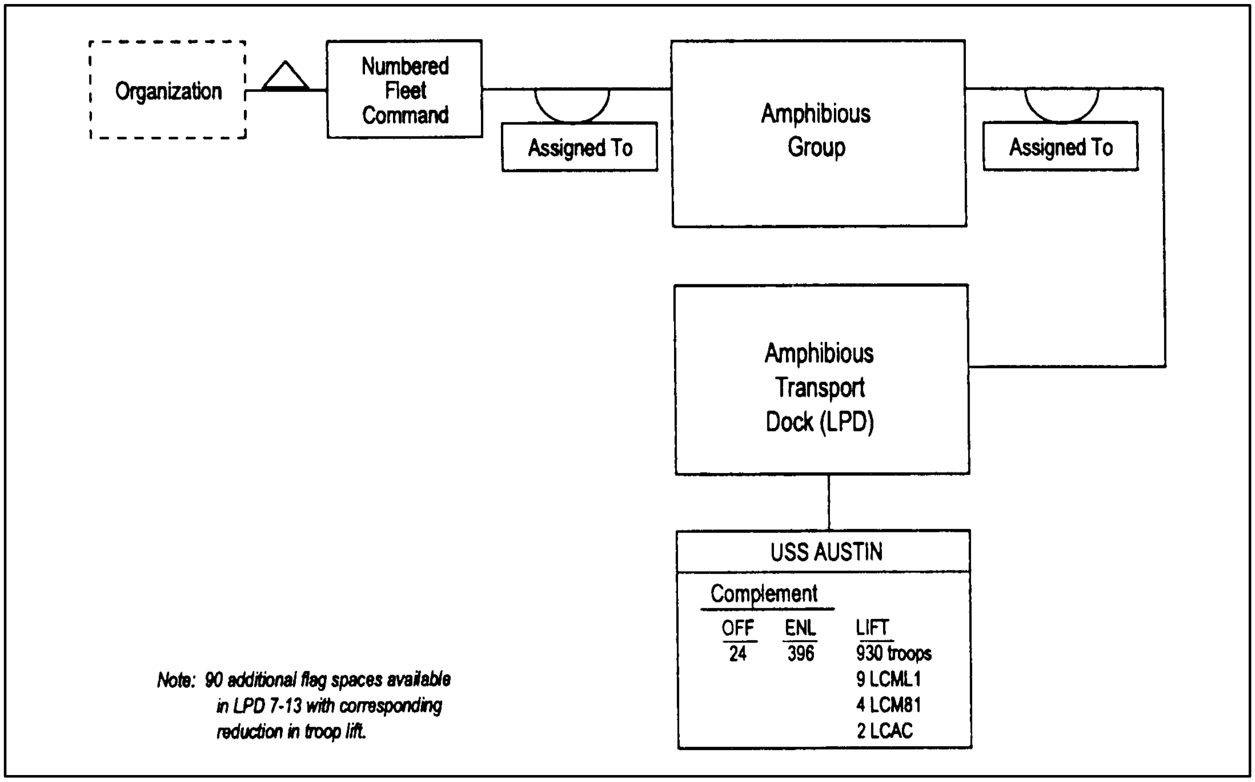


Figure A-19. Navy amphibious transport dock class.

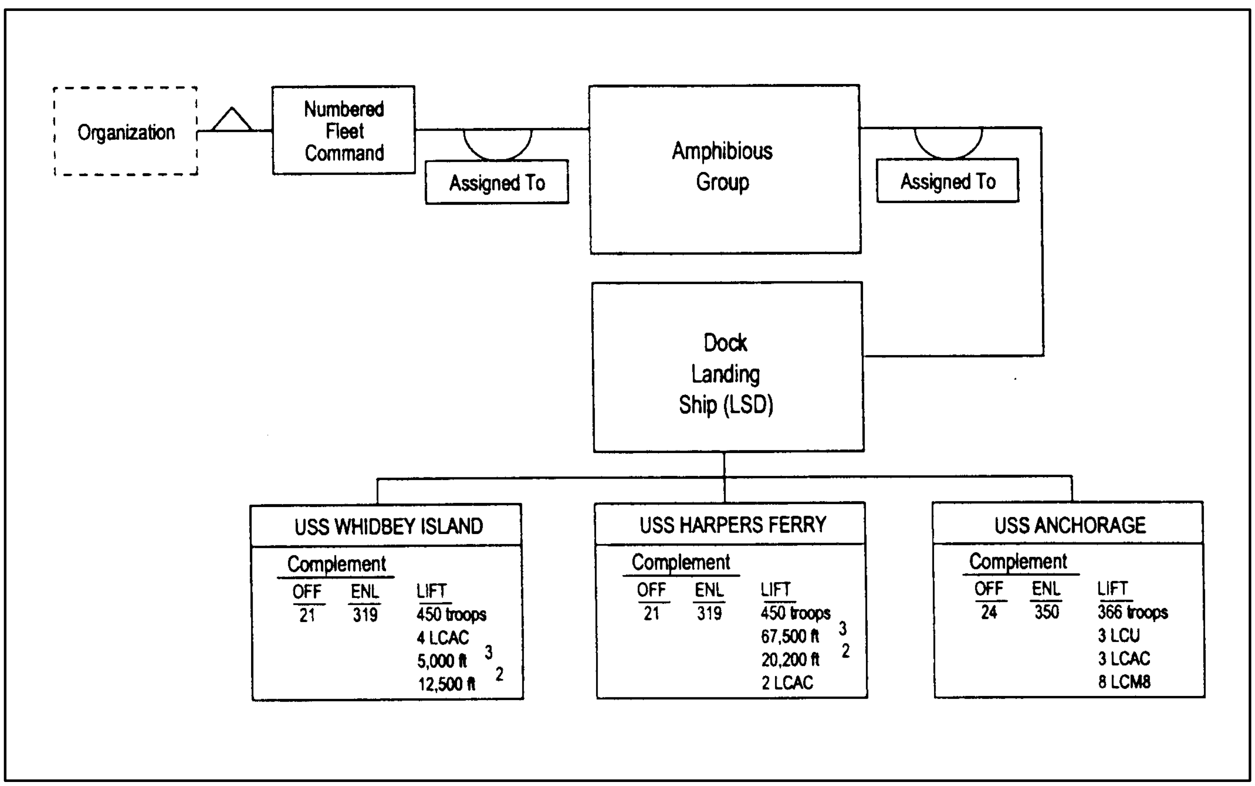


Figure A-20. Navy dock landing ship class.

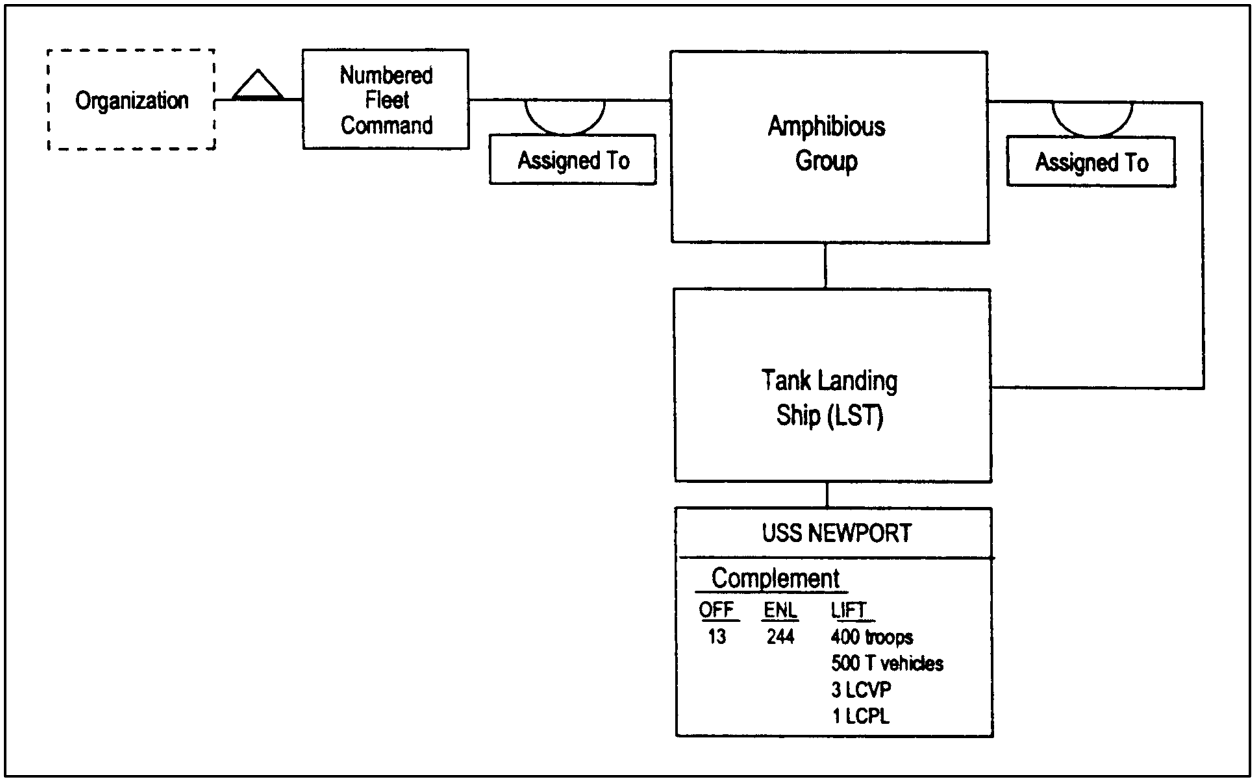


Figure A-21. Navy tank landing ship class.

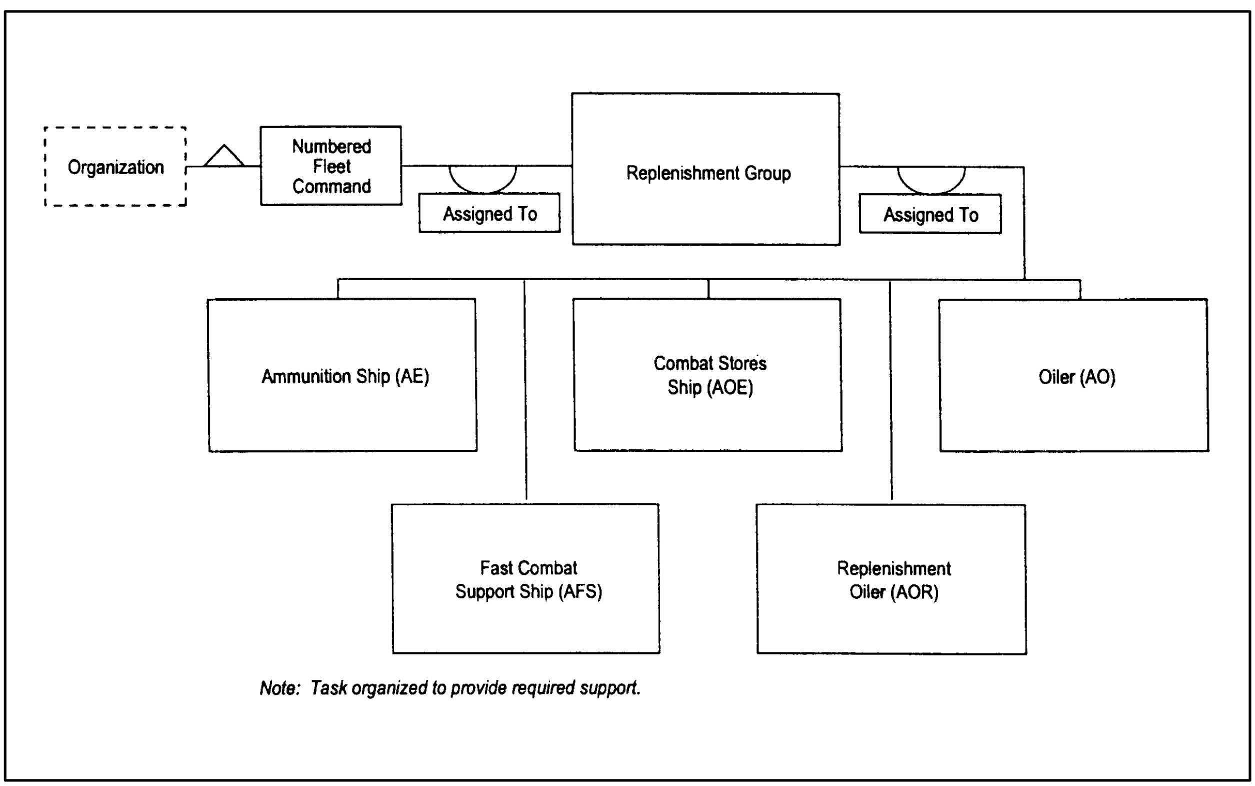


Figure A-22. Navy replenishment group class.

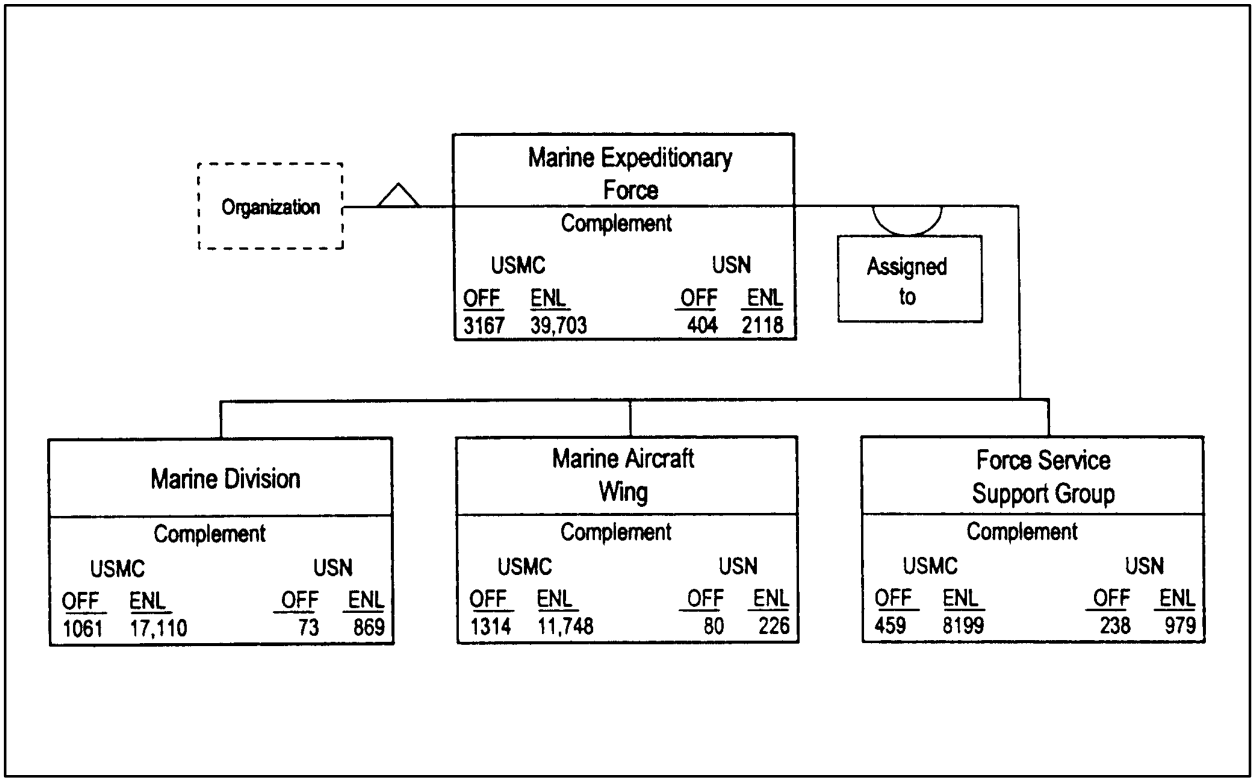


Figure A-23. Marine expeditionary force superclass.

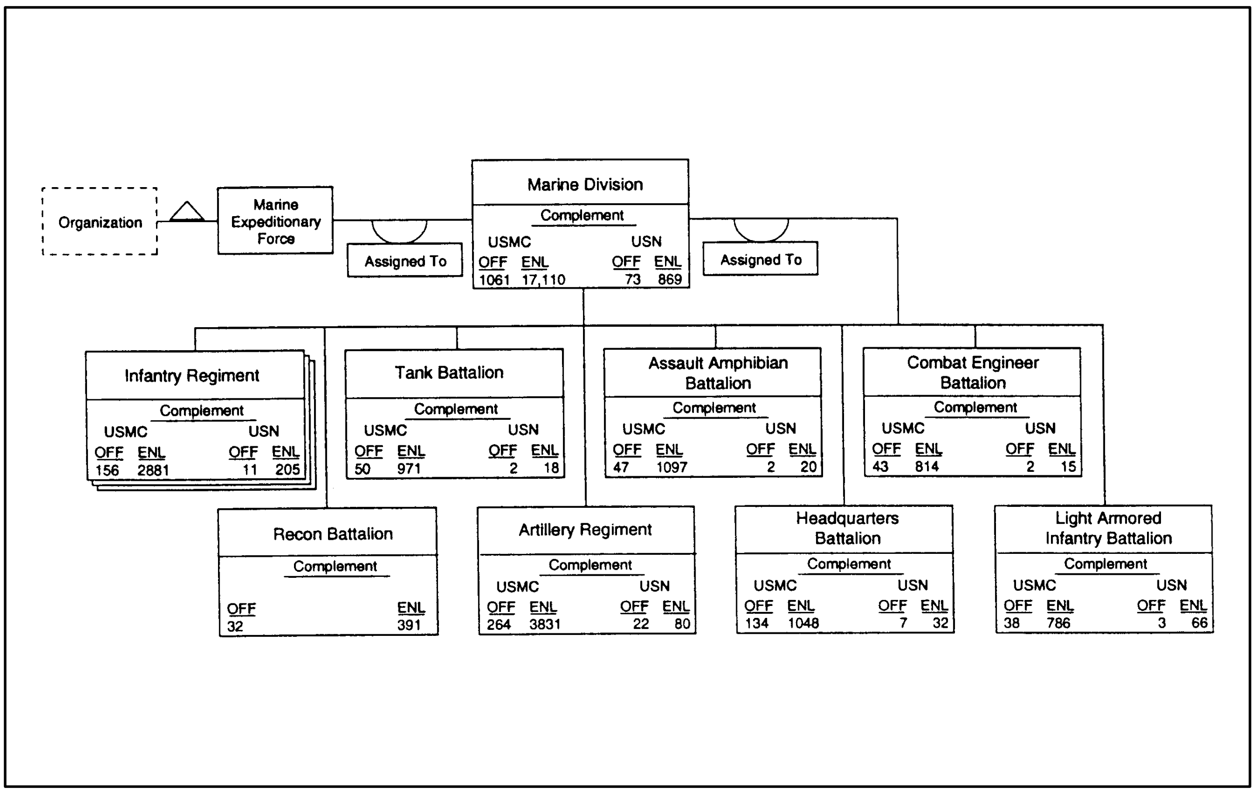


Figure A-24. Marine combat force classes.

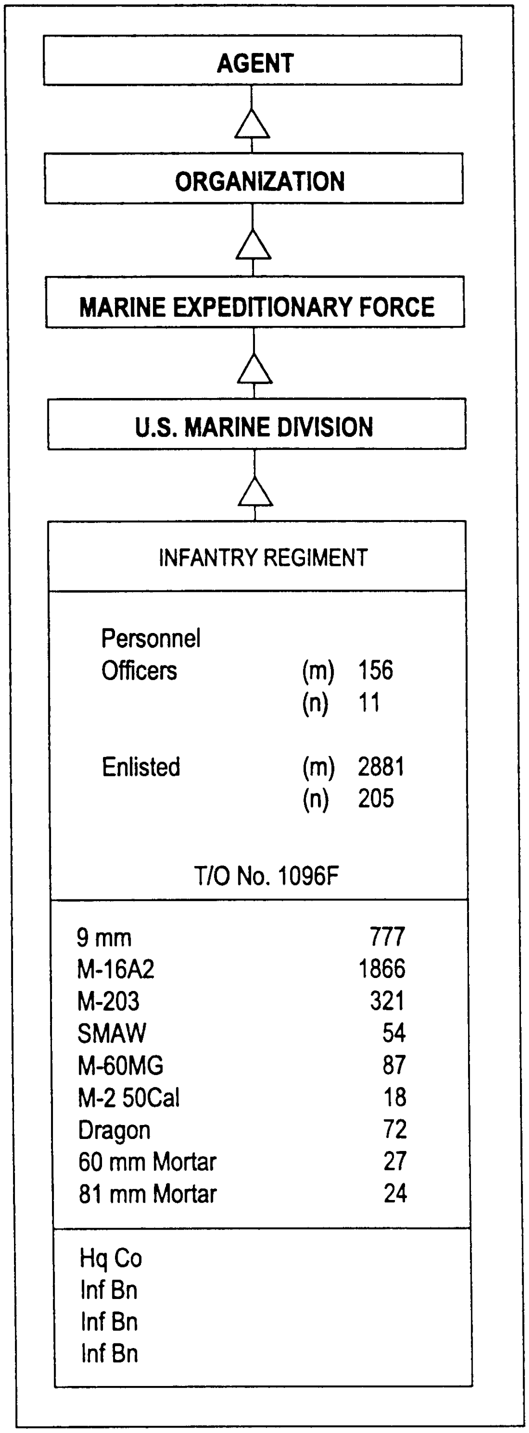


Figure A-25. Infantry regiment.

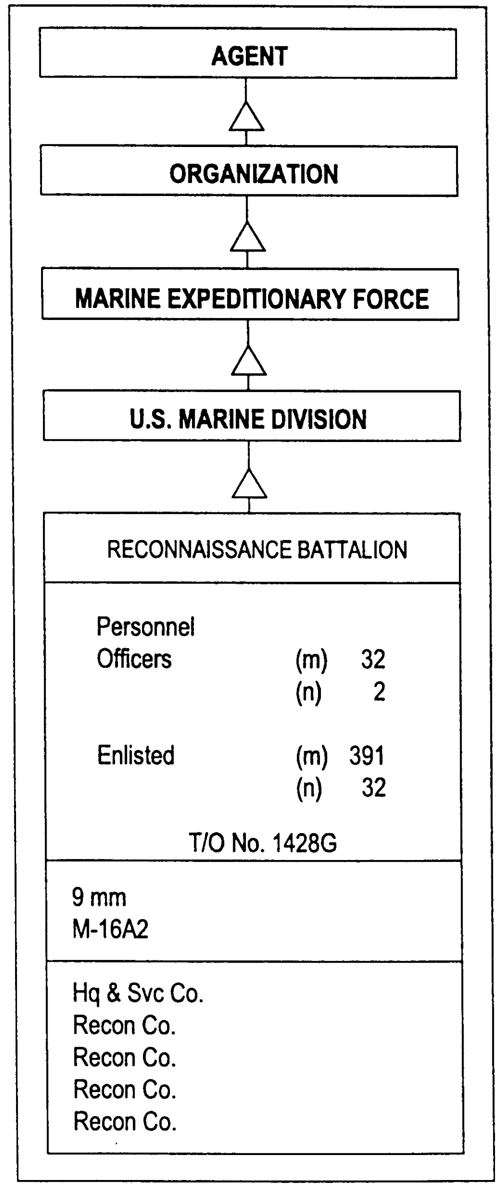


Figure A-26. Reconnaissance battalion.

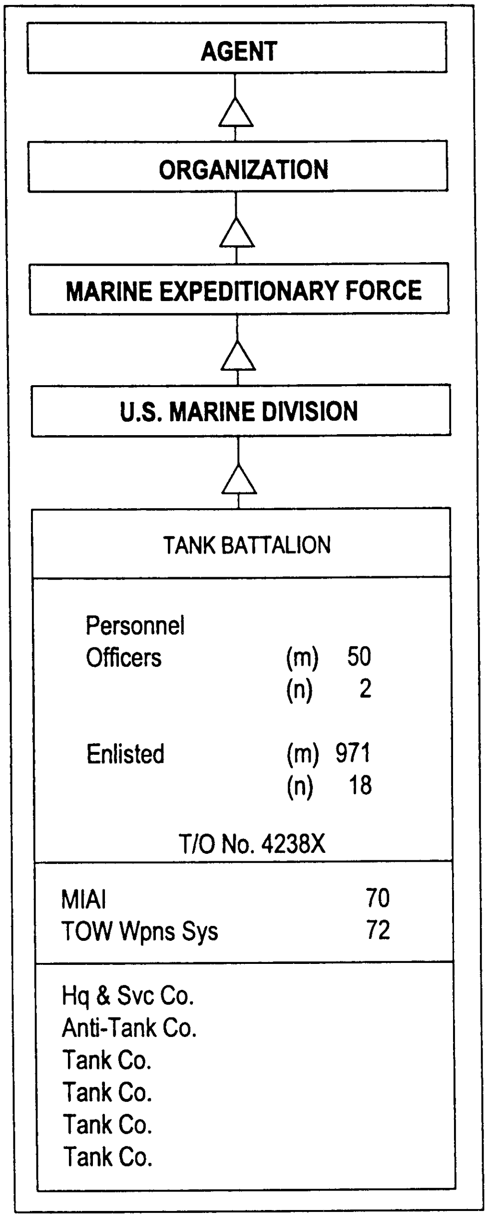


Figure A-27. Tank battalion.

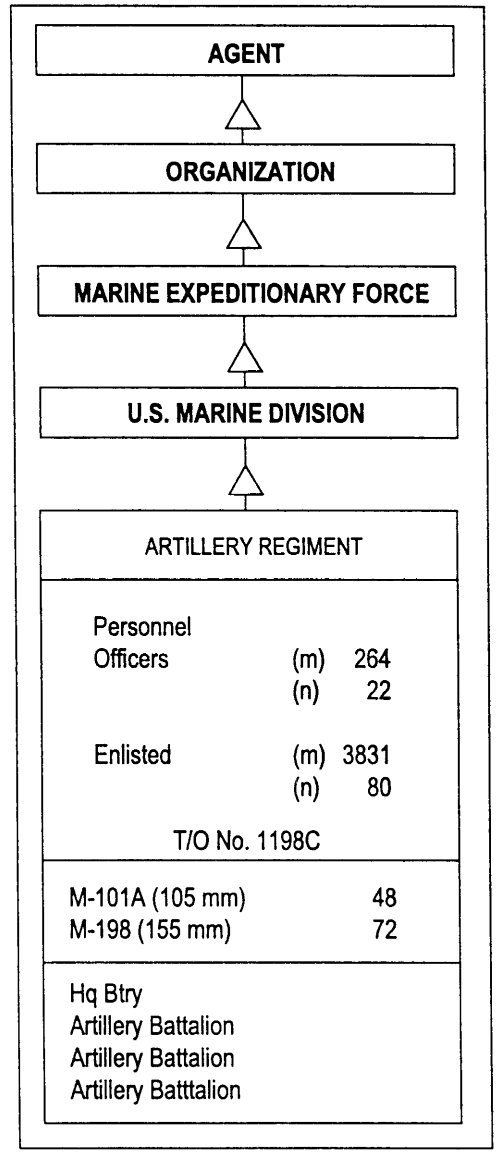


Figure A-28. Artillery regiment.

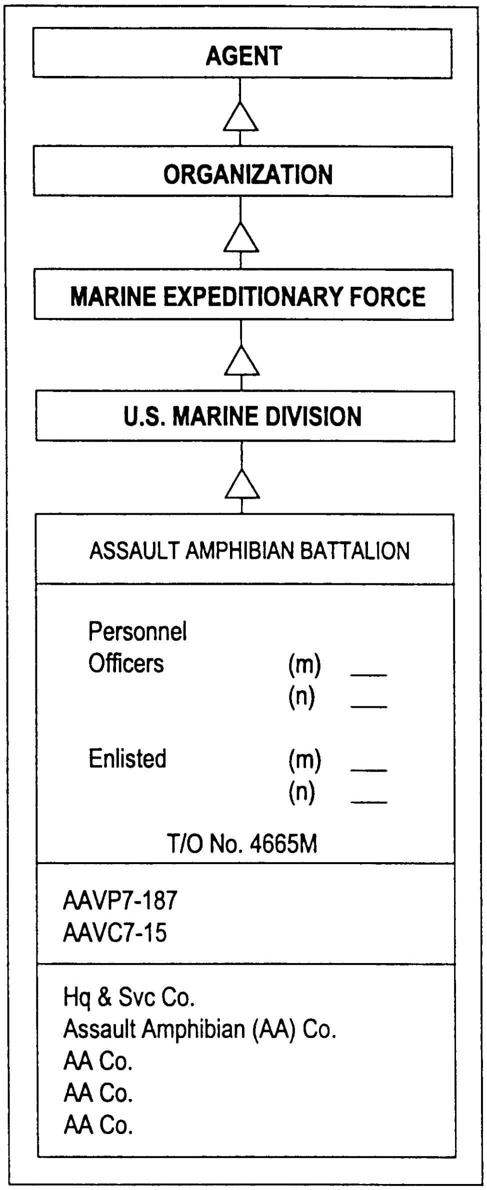


Figure A-29. Assault amphibian battalion.

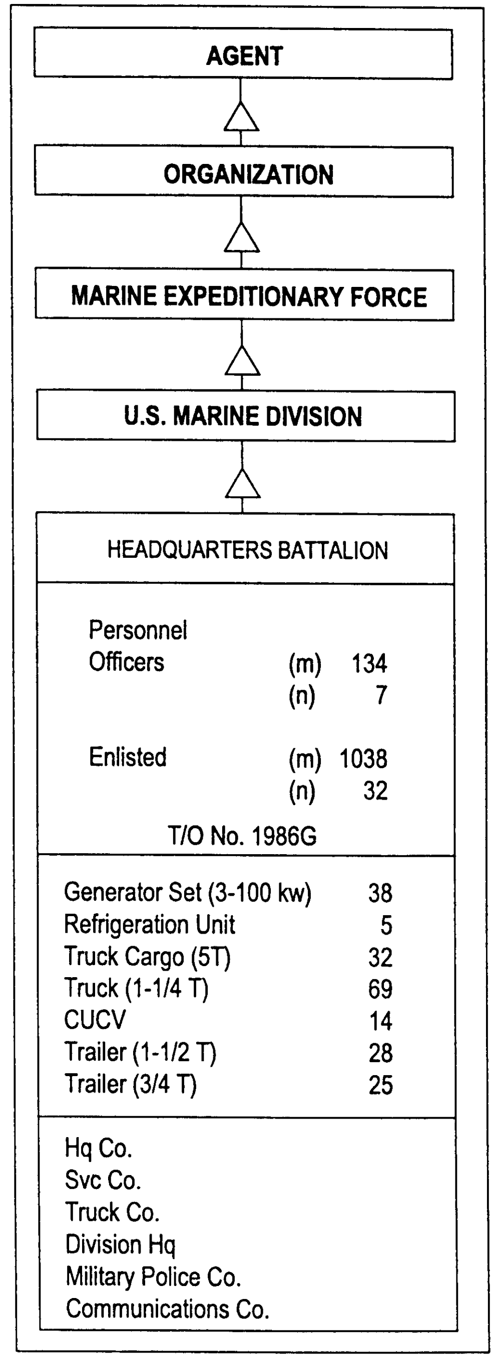


Figure A-30. Headquarters battalion.

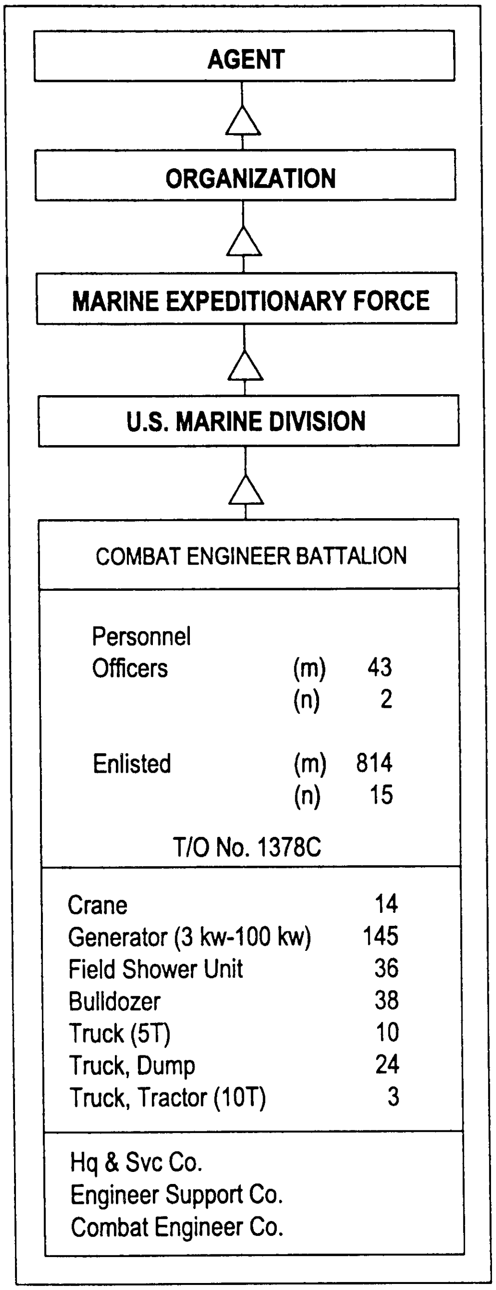


Figure A-31. Combat engineer battalion.

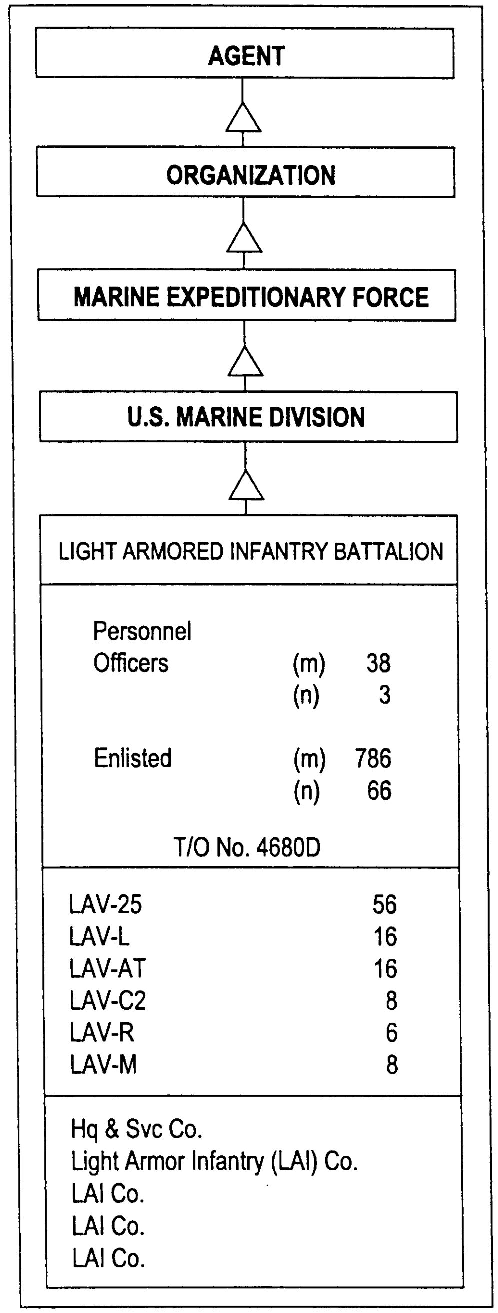


Figure A-32. Light armored infantry battalion.

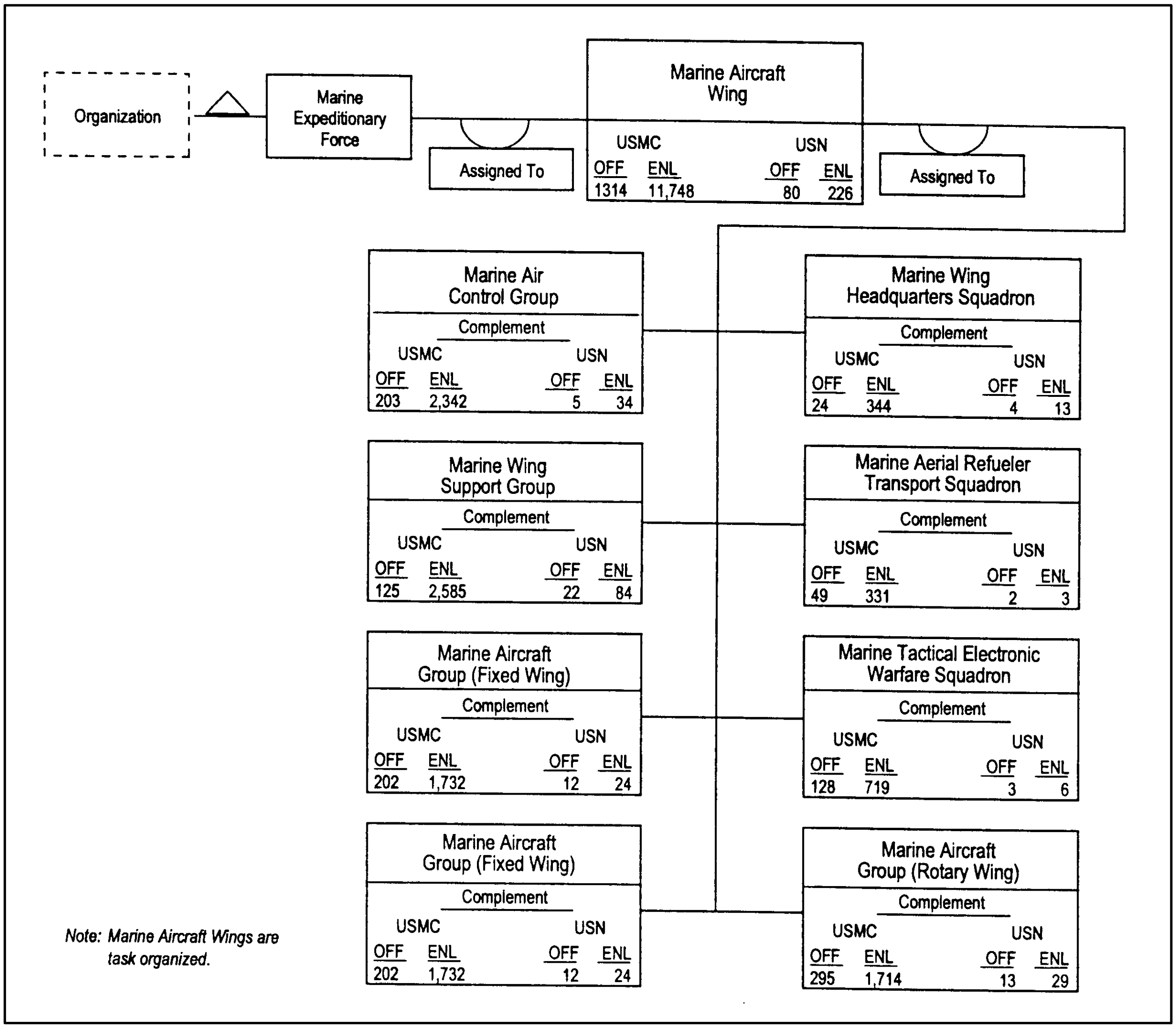


Figure A-33. Marine aircraft wing classes.

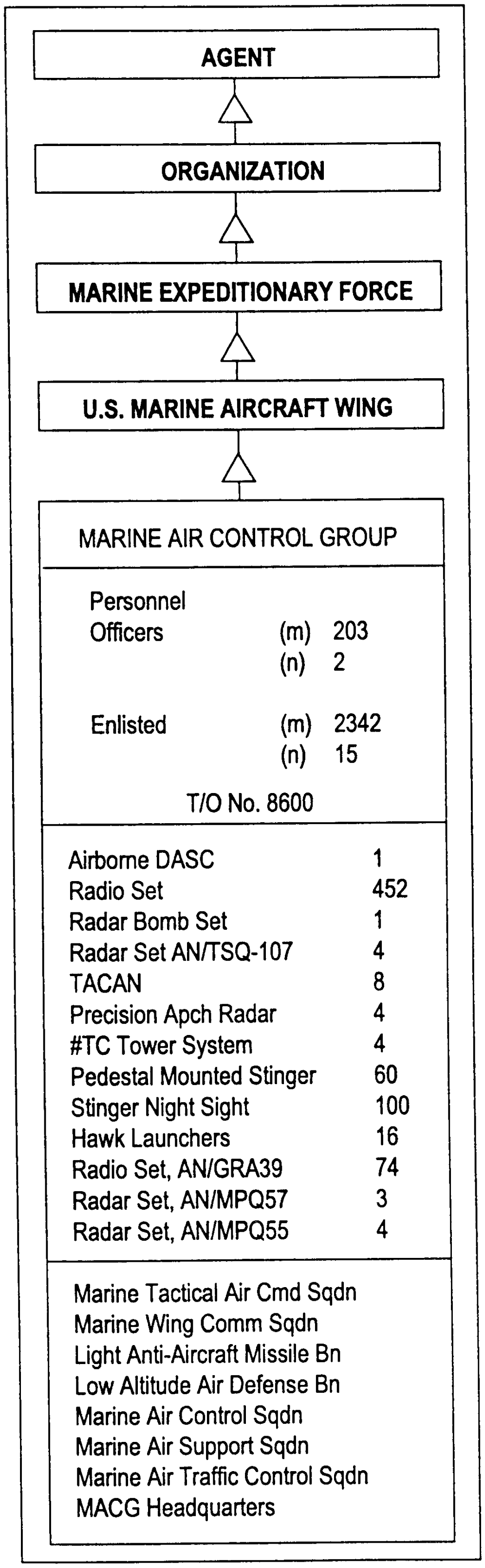


Figure A-34. Marine air control group.

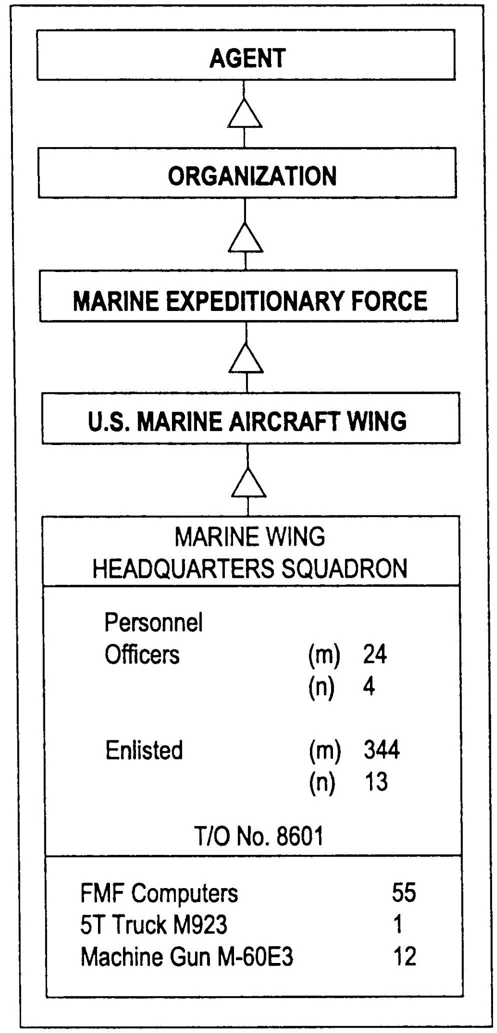


Figure A-35. Marine wing headquarters squadron.

AGENT

ORGANIZATION

MARINE EXPEDITIONARY FORCE

U.S. MARINE AIRCRAFT WING

MARINE WING SUPPORT GROUP

Personnel		
Officers	(m)	125
	(n)	22
Enlisted	(m)	2585
	(n)	84

T/O No. 8701

Bucket Loader	16
Air Compressor	6
Fork Lift	58
Crane	64
Grader	24
ROWP4	30
Runway Sweeper	8
Firefighting Truck 11028FF	16
Ambulance	32
H_2O Purification Set	12
Refrigeration Unit	84
5000 gal. Refueler	40
400 gal. H_2O Trailer	46
1 1/4 T Truck M1008	98
5T Truck M923	104

Marine Wing Support Squadron (rotary wing)
Marine Wing Support Squadron (rotary wing)
Marine Wing Support Squadron (fixed wing)
Marine Wing Support Sqdn (fixed wing)
Hqtrs & Hqtrs Sqdn

Figure A-36. Marine wing support group.

AGENT

ORGANIZATION

MARINE EXPEDITIONARY FORCE

U.S. MARINE AIRCRAFT WING

MARINE AERIAL REFUELER TRANSPORT SQUADRON

Personnel		
Officers	(m)	49
	(n)	2
Enlisted	(m)	331
	(n)	3

T/O No. 8820

KC-130 F/R	12

Marine Aerial Refueler Transport Squadron, Detachment (VMGR, DET)
VMGR, DET

Figure A-37. Marine aerial refueler transport squadron.

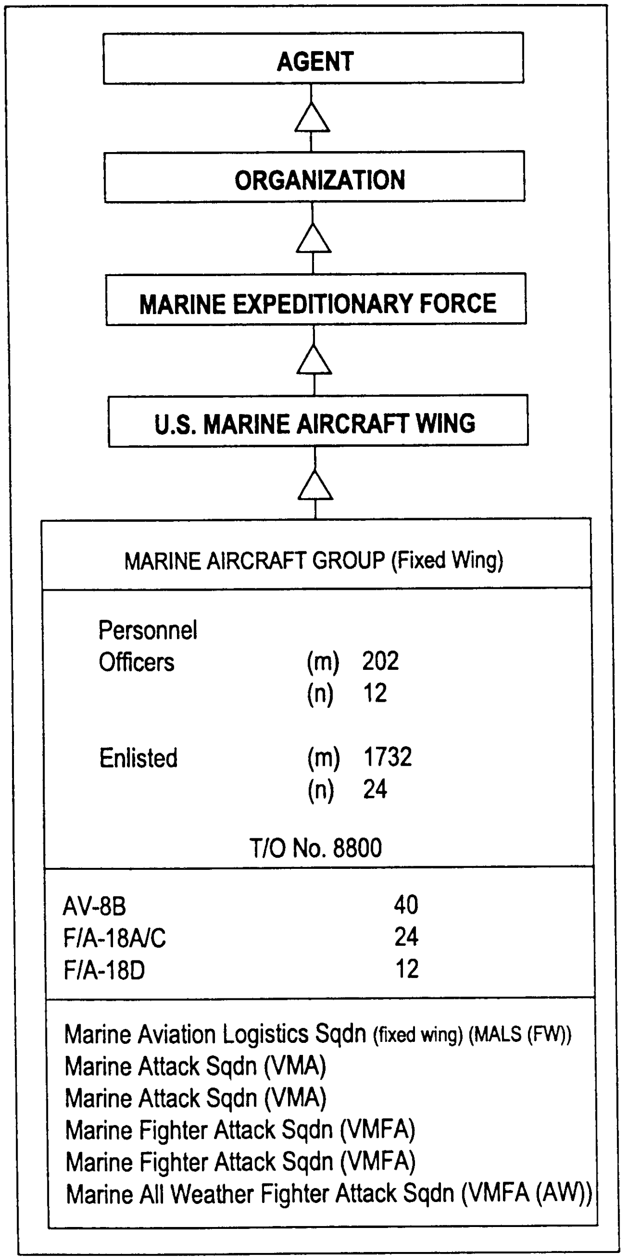


Figure A-38. Marine aircraft group (fixed wing).

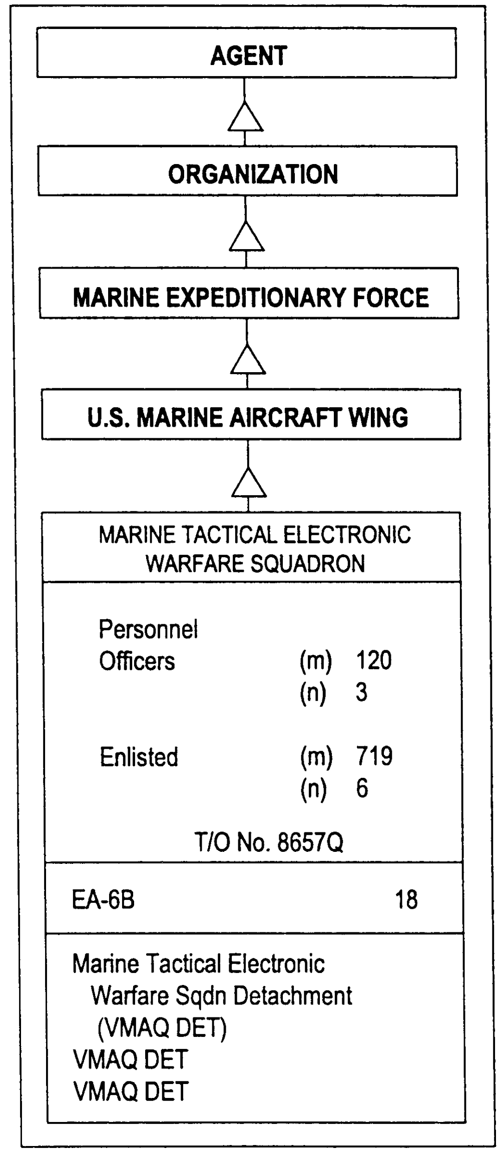


Figure A-39. Marine tactical electronic warfare squadron.

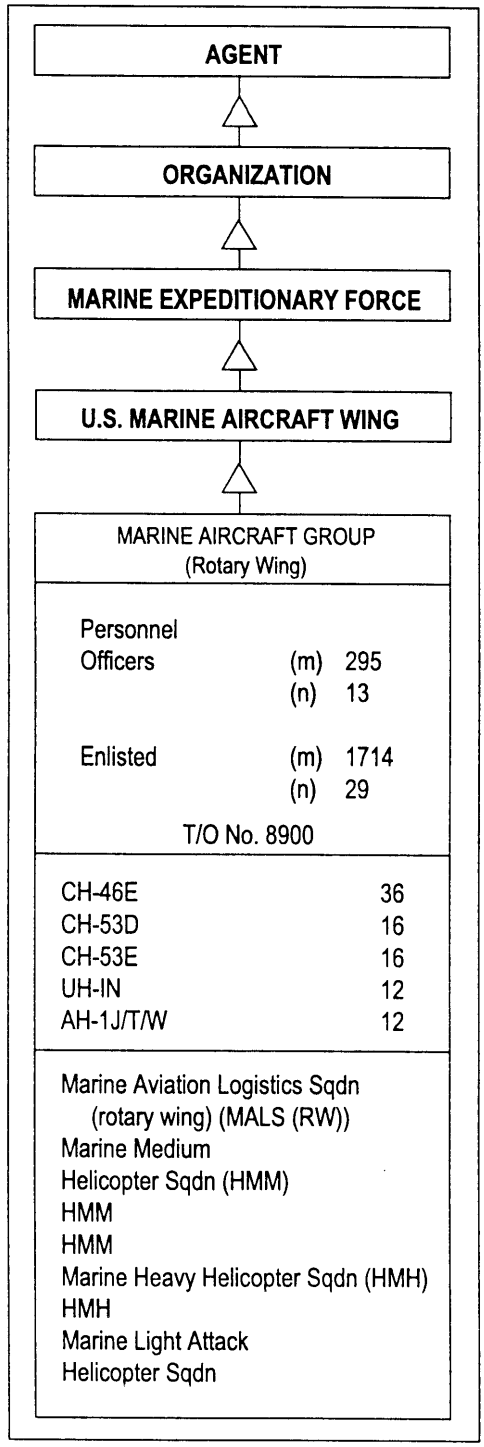


Figure A-40. Marine aircraft group (rotary wing).

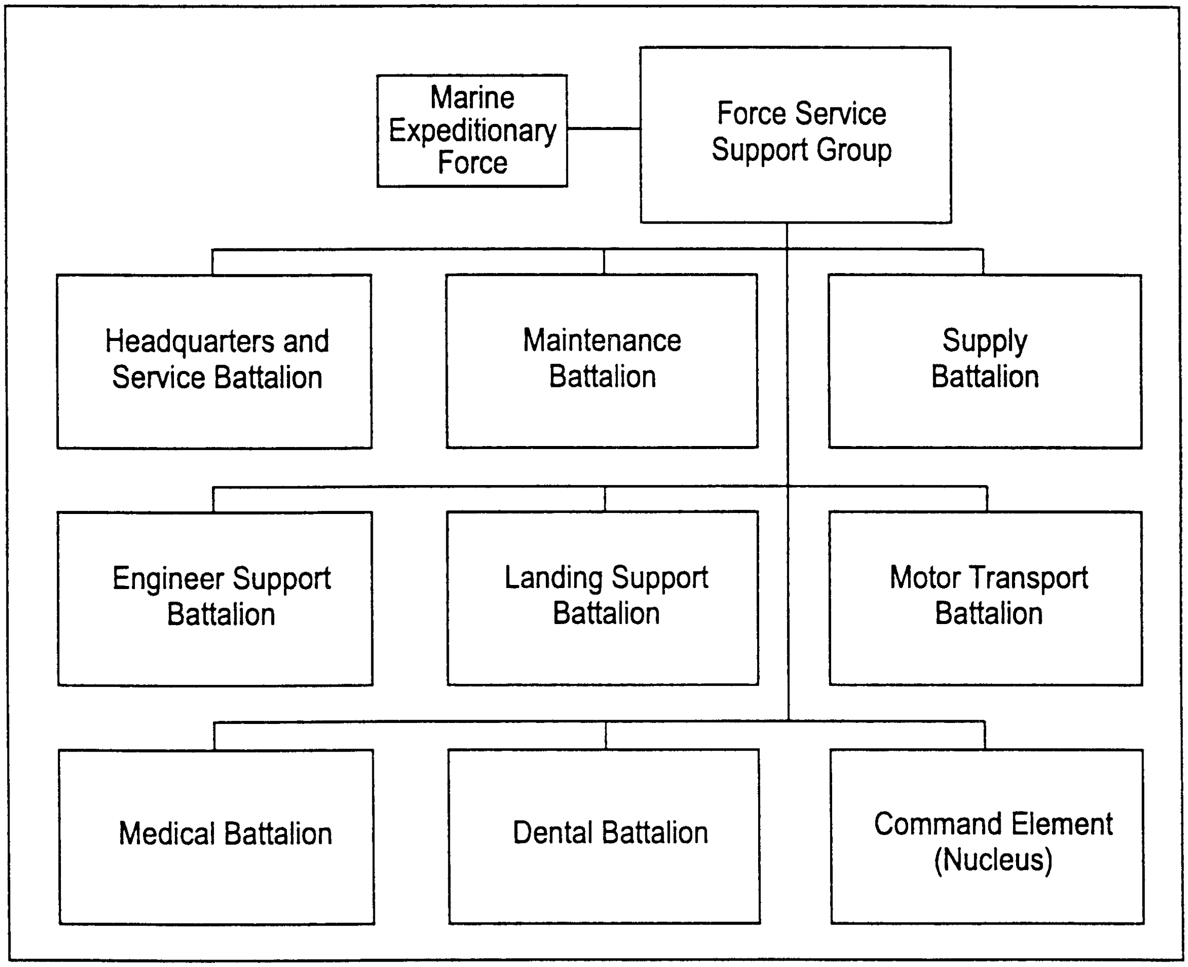


Figure A-41. Marine force service support group.

AGENT

ORGANIZATION

MARINE EXPEDITIONARY FORCE

FORCE SERVICE SUPPORT GROUP

HEADQUARTERS AND SERVICE BATTALION

Personnel		
Officers	(m)	204
	(n)	17
Enlisted	(m)	1488
	(n)	91

T/O No. 3911N

Radio Set	206
5T Truck M923	28
Trailer	35
1-1/4T Truck	47
1200 gal. Fuel Truck	1
1000 gal H_2O Truck	1
Motorcycle	4
Telephone Switchboard	10
Telephone Control	1
Wrecker (5T)	1
Floodlight Set	10

Communication Co.
Military Police Co.
Service Co.
Headquarters Co.

Figure A-42. Headquarters and service battalion.

AGENT

ORGANIZATION

MARINE EXPEDITIONARY FORCE

FORCE SERVICE SUPPORT GROUP

MAINTENANCE BATTALION

Personnel		
Officers	(m)	58
	(n)	2
Enlisted	(m)	1762
	(n)	2

T/O No. 3912N

Automated Data Proc. Equip.	9
Floodlight Set	16
Generator Set	56
Trailer, Cargo	16
1200 gal Fuel Truck	2
5T Truck	16
Wrecker	10
General Purpose Trailer	32
Truck Tractor (5T)	4
AAVR7A1	4

Ordnance Maintenance Co.
Motor Transport
Maintenance Co.
Engineer Maintenance Co.
Hqtrs. and Svc. Co.
Electronics Maint. Co.
General Purpose Maint. Co.

Figure A-43. Maintenance battalion.

AGENT

ORGANIZATION

MARINE EXPEDITIONARY FORCE

FORCE SERVICE SUPPORT GROUP

SUPPLY BATTALION

Personnel		
Officers	(m)	58
	(n)	6
Enlisted	(m)	1292
	(n)	80

T/O No. 3913N

Truck, 5T	7
Firefighting Truck	6
Wrecker	1
400 gal. H_2O Trailer	8
CUCV Truck	6

Hqtrs. and Svc. Co.
Supply Co.
Ammunition Co.
Medical Logistics Co.

Figure A-44. Supply battalion.

AGENT

ORGANIZATION

MARINE EXPEDITIONARY FORCE

FORCE SERVICE SUPPORT GROUP

ENGINEER SUPPORT BATTALION

Personnel		
Officers	(m)	55
	(n)	3
Enlisted	(m)	1538
	(n)	20

T/O No. 3400N

Radio Set	68
Telephone Switchbd	4
Ambulance	1
Generator Set	253
Grader, Road	5
Bucket, 2.5 yd	8
Crane	12
Laundry Unit	36
Concrete Mixer	6
Roller, Compactor	4
Scraper, Tractor	6
Boat, Bridge	9
Bridge (60T)	3
Bridge, Floating Foot	6
Bridge, Med Girder	3
Drum, Collapsible 500 gal	56

Hqtrs and Svc. Co.
Engineer Spt. Co.
Engineer Co.
Bridge Co.
Bulk Fuel Co.

Figure A-45. Engineer support battalion.

AGENT

ORGANIZATION

MARINE EXPEDITIONARY FORCE

FORCE SERVICE SUPPORT GROUP

LANDING SUPPORT BATTALION

Personnel

Officers	(m)	42
	(n)	1
Enlisted	(m)	934
	(n)	1

T/O No. 3915N

Radio Set	103
Grader	6
Bulldozer	12
Tractor, TEREX	30
Forklift	138
400 gal H_2O Trailer	9
Mine Detecting Set	4

Hqtrs and Svc. Co.
Landing Support
Equip. Co.
Beach and Terminal Ops Co.
Landing Support Co.

Figure A-46. Landing support battalion.

AGENT

ORGANIZATION

MARINE EXPEDITIONARY FORCE

FORCE SERVICE SUPPORT GROUP

MOTOR TRANSPORT BATTALION

Personnel

Officers	(m)	30
Enlisted	(m)	915

T/O No. 3916N

5000 gal Refueler	40
65T Tank Transporter	8
Low Bed Trailer	24
22.5T Container Hauler	313
5th Wheel Trailer	32
Trailer Powered MK15	6
20T Powered Trailer	67
400 gal H_2O Trailer	65
Ribbon Bridge Trailer	56
1200 gal Fuel Truck	21
1000 gal H_2O Truck	22
5T Truck M931	40
5T Tractor Truck	40
Wrecker	18
5T Truck M923	218

Hqtrs and Svc. Co.
Direct Support Co.
General Support Co.

Figure A-47. Motor transport battalion.

AGENT

↑

ORGANIZATION

↑

MARINE EXPEDITIONARY FORCE

↑

FORCE SERVICE SUPPORT GROUP

↑

MEDICAL BATTALION

Personnel		
Officers	(m)	6
	(n)	132
Enlisted	(m)	233
	(n)	628

T/O No. 3916N

Ambulance	71
Refrigeration Unit	10
Refrigerator	14
Cargo Trailer	5
H_2O Trailer M149A2	9
Truck M1008	11
Radio Set	78
Telephone Switchbd	7

Collecting and Clearing Co.
Hqtrs. and Svc. Co.
Surgical Support Co.

Figure A-48. Medical battalion.

AGENT

↑

ORGANIZATION

↑

MARINE EXPEDITIONARY FORCE

↑

FORCE SERVICE SUPPORT GROUP

↑

DENTAL BATTALION

Personnel		
Officers		
	(n)	75
Enlisted	(m)	5
	(n)	153

T/O No. 3671N

Ambulance	—
Refrigeration Unit	—
Refrigerator	—
Cargo Trailer	—
H_2O Trailer	—
Truck M1008	—

Hqtrs. and Svc. Co.
Dental Co.
Dental Co.
Dental Co.

Figure A-49. Dental battalion.

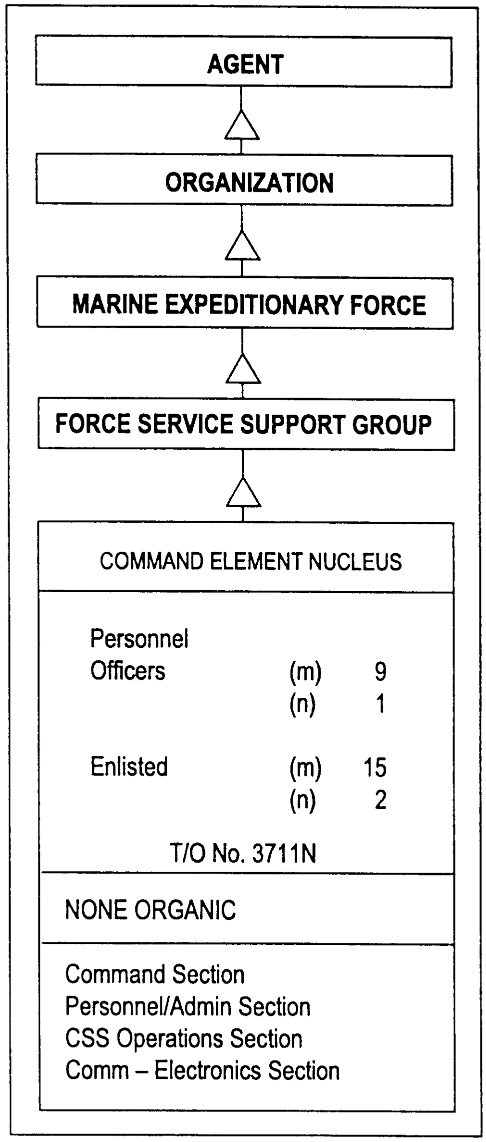


Figure A-50. Command element nucleus.

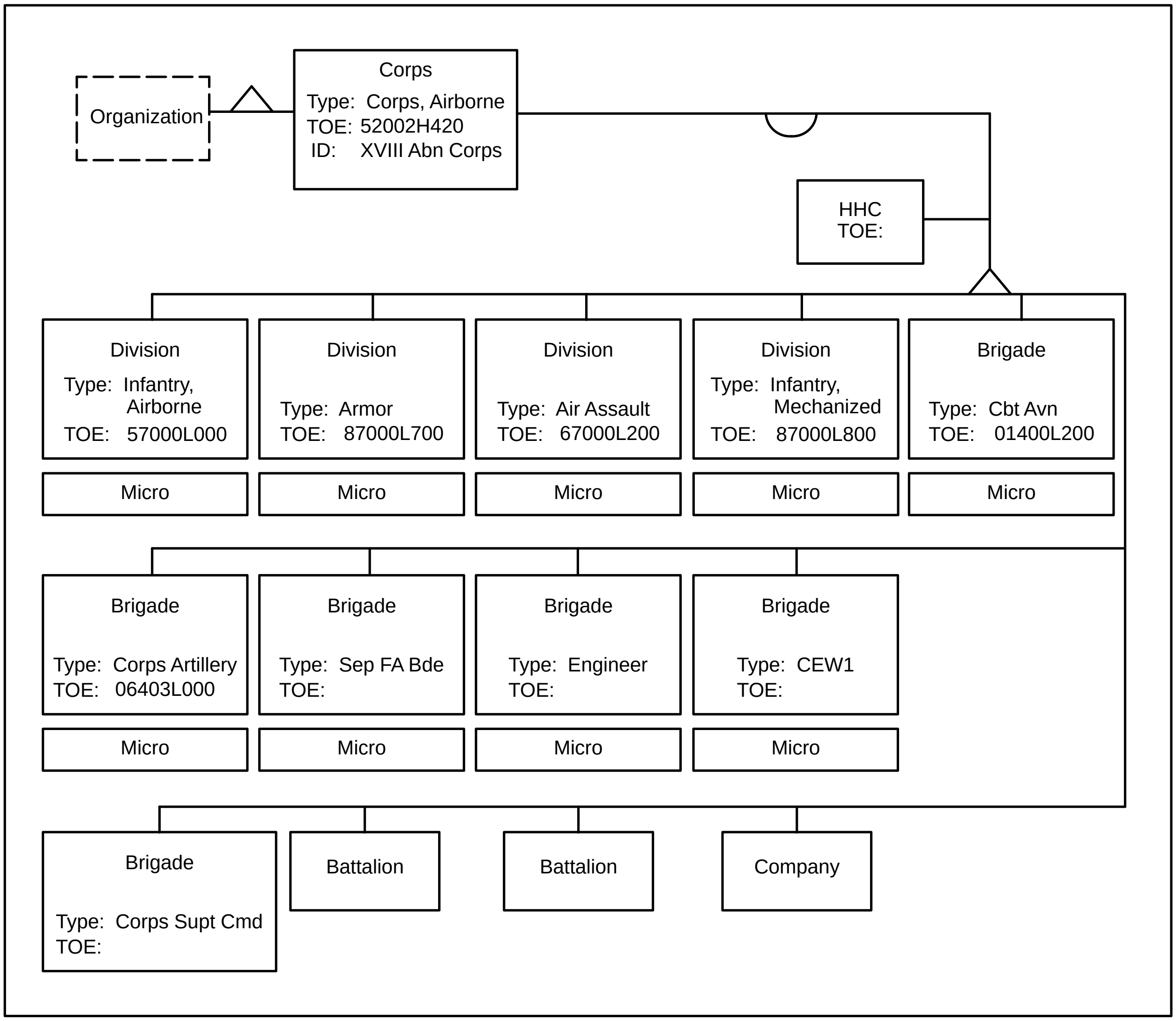


Figure A-51. Macro corps.

Level:	**Division**
Type:	**Airborne Inf**
TOE:	**57000L000**
ID:	**82nd Abn Div**

Personnel Strength	
Off	124
Enl	11,873
CBT Pwr Equivalent	
Major Equipment	
M1A1	
M1A2	
M2A2	
M3A1	
M3A2	
M113A3	
M577	
M60A1	
M60A2	
M60A3	
AH-1F	12
AH-1S	
AH-1P	
AH-1H	
AH-64	18
CH-47	
UH-1	
UH-60A	43
OH-58C	43
OH-58	1
M992A1	
MLRS	
203mm	
155mm	
105mm (M119)	54
ITV	
TOW ATGM	188
107mm Mort	
81mm Mort	36
60mm Mort	54
ADA Gun	27
Stinger	180
MK19	237
SAW	1,358
150cal m2	
AVLB	
2.5 Ton	436
HWMMV	1,217
5 Ton	100
W/S250 Shelter	204
Tanker, 250 gal	
M16A2	9,608
(M88) Armed Recov Veh	
CEV	

Assigned Subunits

Div HHC (0-1)
MVR BDE HHC (0-3)
- *Inf Battalions (0-a) (light, abn, a/aslt, mech)*
- *Armor Battalions (0-6) (M60, M1A1/2)*

Div Arty HHC (0-1)
- *FA Battalions (0-3) (155,105)*
- *(Tab, MLRS)*

Avn Bde HHC
- *ATK Helo Bn (0-1)*
- *Assault Helo Bn (0-1)*
- *Command Avn Co (0-1)*

Division Supt Com HHC (0-1)
- *Med Bn (0-1)*
- *Transport Bn (0-1)*
- *Mamt Bn (0-1)*

Engineer Bn
CEW1 Bn
MP Co
CML Co

Figure A-52. Airborne infantry.

Level:	**Division**
Type:	**Armor**
TOE:	**87000L700**
ID:	**1 Armored Div**

Personnel Strength	
Off	1,521
Enl	15,257
CBT Pwr Equivalent	
Major Equipment	
M1A1	348
M1A2	
M2A2	216
M3A1	8
M3A2	108
M113A3	365
M577	185
M60A1	
M60A2	
M60A3	
AH-1F	8
AH-1S	8
AH-1P	6
AH-1H	18
AH-64	
CH-47	
UH-1	
UH-60A	21
OH-58C	37
OH-58	
M992A1	72
MLRS	9
203mm	
155mm	72
105mm (M119)	
ITV	48
TOW ATGM	
107mm Mort	66
81mm Mort	54
60mm Mort	
ADA Gun	27
Stinger	
MK19	323
SAW	504
150cal m2	756
AVLB	36
2.5 Ton	615,119
HWMMV	1,106
5 Ton	248,213,34
W/S250 Shelter	
Truck, 250 gal	208
M16A2	11,475
Armed Recov Veh	94
Trailer, 5000 gal	64
CEV	18

Assigned Subunits

Div HHC (0-1)
MVR BDE HHC (0-3)
- *Inf Battalions (0-4a) (light, abn, a/aslt, mech)*
- *Armor Battalions (0-6) (M60, M1A1/2)*

Div Arty HHC (0-1)
- *FA Battalions (0-3) (155,105)*
- *FA Btrys (0-*) (Tab, MLRS, 203mm, 155)*

Avn Bde HHC
- *ATK Helo Bn (0-1)*
- *Assault Helo Bn (0-1)*
- *Command Avn Co (0-1)*

Division Supt Com HHC (0-1)
- *Med Bn (0-1)*
- *Transport Bn (0-1)*
- *Mamt Bn (0-1)*

Engineer Bn
CEW1 Bn
MP Co
CML Co

Figure A-53. Armor.

Level:	**Division**
Type:	**Air Assault**
TOE:	**67000L200**
ID:	**101st Air Assault**

Personnel Strength	
Off	1,785
Enl	13,964
CBT Pwr Equivalent	
Major Equipment	
M1A1	0
M1A2	
M2A2	
M3A1	
M3A2	
M113A3	
M577	
M60A1	
M60A2	
M60A3	
AH-1F	16
AH-1S	
AH-1P	16
AH-1H	
AH-64	72
CH-47D	48
UH-1H	33
UH-60A	128
OH-58C	91
OH-58	1
M992A1	
MLRS	
203mm	
155mm	
105mm (M119)	54
ITV	
TOW ATGM	180
107mm Mort	
81mm Mort	36
60mm Mort	54
ADA Gun	27
Stinger	180
MK19	126
SAW	774
150cal m2	
AVLB	
2.5 Ton	406
HWMMV	1,283
5 Ton	222
W/S250 Shelter	268
Tanker, 250 gal	72
M16A2	
(M88) Armed Recov Veh	
Trailer, 5000 gal	
CEV	

Assigned Subunits

Div HHC (0-1)
MVR BDE HHC (0-3)
Inf Battalions (0-a) (light, abn, a/aslt, mech)
Armor Battalions (0-6) (M60, M1A1/2)
Div Arty HHC (0-1)
FA Battalions (0-3) (155,105)
FA Btrys (0-) (Tab, MLRS, 203mm, 155)*
Avn Bde HHC
ATK Helo Bn (0-2)
Assault Helo Bn (0-1)
Command Avn Co (0-1)
Division Supt Com HHC (0-1)
Med Bn (0-1)
Transport Bn (0-1)
Mamt Bn (0-1)
Engineer Bn
CEW1 Bn
MP Co
CML Co

Figure A-54. Air assault.

Level:	**Division**
Type:	**Inf (mechanized)**
TOE:	**87000L800**
ID:	

Personnel Strength	
Off	1,530
Enl	15,524
CBT Pwr Equivalent	
Major Equipment	
M1A1	290
M1A2	
M2A2	270
M3A1	10
M3A2	110
M113A3	370
M577	185
M60A1	
M60A2	
M60A3	
AH-1F	8
AH-1S	
AH-1P	8
AH-1H	6
AH-64	18
CH-47D	
UH-1	
UH-60A	21
OH-58C	37
OH-58	72
M992A1	9
MLRS	
203mm	
155mm	72
105mm (M119)	
ITV	60
TOW ATGM	
107mm Mort	66
81mm Mort	45
60mm Mort	
ADA Gun	27
Stinger	
MK19	348
SAW	420
150cal m2	742
AVLB	36
2.5 Ton	741
HWMMV	1,111
5 Ton	460
W/S250 Shelter	
Tanker, 250 gal	208
M16A2	11,771
(M88) Armed Recov Veh	94
Trailer, 5000 gal	64
CEV	18

Assigned Subunits

- Div HHC (0-1)
- MVR BDE HHC (0-3)
  - Inf Battalions (0-5a) (light, abn, a/aslt) mech)
  - Armor Battalions (0-6) (M60, M1A1/2)
- Div Arty HHC (0-1)
  - FA Battalions (0-3) (155,105) (Tab, MLRS)
- Avn Bde HHC
  - ATK Helo Bn (0-1)
  - Assault Helo Bn (0-1)
  - Command Avn Co (0-1)
- Division Supt Com HHC (0-1)
  - Med Bn (0-1)
  - Transport Bn (0-1)
  - Maint Bn (0-1)
- Engineer Bn
- CEWI Bn
- MP Co
- CML Co

Figure A-55. Infantry (mechanized).

Level: **Brigade**
Type: **Corps Avn Bde**
TOE: **01400L200**
ID:

Personnel Strength	
Off	1,053
Enl	2,867
CBT Pwr Equivalent	
Major Equipment	
M1A1	
M1A2	
M2A2	
M2A2	
M3A1	
M3A2	
M113A3	
M577	
M60A1	
M60A2	
M60A3	
AH-1F	42
AH-1E	12
AH-1P	12
AH-1H	34
AH-64	72
CH-47D	64
UH-1	
UH-60A	108
OH-58C	108
OH-58	6
M992A1	
MLRS	
203mm	
155mm	
105mm (M119)	
ITV	
TOW ATGM	
107mm Mort	
81mm Mort	
60mm Mort	
ADA Gun	
Stinger	
MK19	
SAW	
150cal m2	
AVLB	
2.5 Ton	333
HWMMV	375
5 Ton	577
W/S250 Shelter	14
Truck, 250 gal	75
M16A2	
Armed Recovery Vehicle	
CEV	
Trailer, 5000 gal	
U-21	5

Assigned Subunits

- Div HHC (0-1)
- MVR BDE HHC (0-3)
  - *Inf Battalions (0-9) (light, abn, a/aslt, mech)*
  - *Armor Battalions (0-6) (M60, M1A1/2)*
- Div Arty HHC (0-1)
  - *FA Battalions (0-3) (155,105)*
  - *FA Btrys (0-*) (Tab, MLRS, 203mm, 155)*
- Avn Bde HHC
  - *ATK Helo Bn (0-2)*
  - *Assault Helo Bn (0-1)*
  - *Command Avn Co (0-1)*
- Division Supt Com HHC (0-1)
  - *Med Bn (0-1)*
  - *Transport Bn (0-1)*
  - *Mamt Bn (0-1)*
- Engineer Bn
- CEW1 Bn
- MP Co
- CML Co

Figure A-56. Corps aviation brigade.

Level: **Brigade**
Type: **Corps Artillery**
TOE: **06403L000**
ID:

Personnel Strength	
Off	199
Enl	1,922 + 357 = 2,289
CBT Pwr Equivalent	
Major Equipment	
M1A1	
M1A2	
M2A2	
M3A1	
M3A2	
M113A3	
M577	42
M60A1	
M60A2	
M60A3	
AH-1F	
AH-1S	
AH-1P	
AH-1H	
AH-64	
CH-47	
UH-1	
UH-60A	
OH-58C	
OH-58	
M992A1	72
MLRS	27
203mm	72
155mm	
105mm (M119)	
ITV	
TOW ATGM	
107mm Mort	
81mm Mort	
60mm Mort	
ADA Gun	
Stinger	
MK19	72
SAW	
150cal m2	105
AVLB	
2.5 Ton	3,4,4,1,3,69,15,13
HWMMV	4,11,11,1,5,36,53
5 Ton	4,4,36
W/S250 Shelter	
Truck, 250 gal	3,7
M16A2	1,809
Armed Recov Veh	13
Trailer, 5000 gal	
CEV	

Assigned Subunits

Div HHC (0-1)
MVR BDE HHC (0-3)
Inf Battalions (0-9) (light, abn, a/aslt, mech)
Armor Battalions (0-6) (M60, M1A1/2)
Div Arty HHC (0-1)
FA Battalions (0-3) (155,105,203)
3 Bus w/TOE: 06445J420
1 MLRS Bn TOE:
FA Btrys (0-) (Tab TOE: 06413L000, MLRS, 203mm, 155)*
Avn Bde HHC
ATK Helo Bn (0-2)
Assault Helo Bn (0-1)
Command Avn Co (0-1)
Division Supt Com HHC (0-1)
Med Bn (0-1)
Transport Bn (0-1)
Mamt Bn (0-1)
Engineer Bn
CEW1 Bn
MP Co
CML Co

Figure A-57. Corps artillery.

Level:	**Brigade**
Type:	**FA Brigade**
TOE:	**06402L200**
ID:	

Personnel Strength	
Off	
Enl	
CBT Pwr Equivalent	
Major Equipment	
M1A1	
M1A2	
M2A2	
M3A1	
M3A2	
M113A3	
M577	27
M60A1	
M60A2	
M60A3	
AH-1F	
AH-1S	
AH-1P	
AH-1H	
AH-64	
CH-47	
UH-1	
UH-60A	
OH-58C	
OH-58	
M992A1	
MLRS	
203mm	54
155mm	
105mm (M119)	
ITV	
TOW ATGM	
107mm Mort	
81mm Mort	
60mm Mort	
ADA Gun	
Stinger	
MK19	
SAW	
150cal m2	66
AVLB	
2.5 Ton	3,1,60,21
HWMMV	9,2,45,27,87,8
5 Ton	10,1,4
W/S250 Shelter	9,6
Tanker, 250 gal	
M16A2	135,1800
M88 Armed Recov Veh	9
Trailer, 5000 gal	
CEV	

Assigned Subunits

Div HHC (0-1)
MVR BDE HHC (0-3)
- *Inf Battalions (0-9) (light, abn, a/aslt, mech)*
- *Armor Battalions (0-6) (M60, M1A1/2)*

Div Arty HHC (0-1)
- *FA Battalions (0-3) (155,105,203)*
- *FA Btrys (0-*) (Tab, MLRS, 203mm, 155)*

Avn Bde HHC
- *ATK Helo Bn (0-2)*
- *Assault Helo Bn (0-1)*
- *Command Avn Co (0-1)*

Division Supt Com HHC (0-1)
- *Med Bn (0-1)*
- *Transport Bn (0-1)*
- *Mamt Bn (0-1)*

Engineer Bn
CEW1 Bn
MP Co
CML Co
3 x 8" Bus TOE:
Tab Btry TOE:

Figure A-58. FA brigade.

Level:	**Brigade**
Type:	**Engineer Corps Bde**
TOE:	**05330L000**
ID:	

Personnel Strength	
Off	92
Enl	1,262
CBT Pwr Equivalent	
Major Equipment	
M1A1	
M1A2	
M2A2	
M3A1	
M3A2	
M113A3	87
M577	9
M60A1	
M60A2	
M60A3	
AH-1F	
AH-1S	
AH-1P	
AH-1H	
AH-64	
CH-47	
UH-1	
UH-60A	
OH-58C	
OH-58	
M992A1	
MLRS	
203mm	
155mm	
105mm (M119)	
ITV	
TOW ATGM	
107mm Mort	
81mm Mort	
60mm Mort	
ADA Gun	
Stinger	
MK19	
SAW	
150cal m2	
AVLB	36
2.5 Ton	35
HWMMV	115
5 Ton	9
W/S250 Shelter	
Tanker, 250 gal	12
M16A2	98
M88 Armed Recov Veh	6
Trailer, 5000 gal	
CEV	18

Assigned Subunits

- Div HHC (0-1)
- MVR BDE HHC (0-3)
  - *Inf Battalions (0-a) (light, abn, a/aslt, mech)*
  - *Armor Battalions (0-6) (M60, M1A1/2)*
- Div Arty HHC (0-1)
  - *FA Battalions (0-3) (155,105)*
  - *FA Btrys (0-*) (Tab, MLRS, 203mm, 155)*
- Avn Bde HHC
  - *ATK Helo Bn (0-1)*
  - *Assault Helo Bn (0-1)*
  - *Command Avn Co (0-1)*
- Division Supt Com HHC (0-1)
  - *Med Bn (0-1)*
  - *Transport Bn (0-1)*
  - *Mamt Bn (0-1)*
- Engineer Bn
- CEW1 Bn
- MP Co
- CML Co

Figure A-59. Engineer corps brigade.

Level: Brigade
Type: CEWI
TOE: 34400L200
ID:

Personnel Strength	
Off	316
Enl	1,457
CBT Pwr Equivalent	
Major Equipment	
M1A1	
M1A2	
M2A2	
M3A1	
M3A2	
M113A3	14
M577	
M60A1	
M60A2	
M60A3	
AH-1F	
AH-1S	
AH-1P	
AH-1H	
AH-64	
CH-47	
UH-1	
UH-60A	
OH-58C	
OH-58	
M992A1	
MLRS	
203mm	
155mm	
105mm (M119)	
ITV	
TOW ATGM	
107mm Mort	
81mm Mort	
60mm Mort	
ADA Gun	
Stinger	
MK19	
SAW	
150cal m2	
AVLB	
2.5 Ton	73,10
HWMMV	64,70,54,38
5 Ton	15,18,9
W/S250 Shelter	
Tanker, 250 gal	4
M16A2	1,462
M88 Armed Recov Veh	4
Trailer, 5000 gal	
CEV	
OV-10	10
U-21	6
C-12	6

Assigned Subunits

- Div HHC (0-1)
- MVR BDE HHC (0-3)
  - Inf Battalions (0-a) light, abn, a/aslt, mech)
  - Armor Battalions (0-6) (M60, M1A1/2)
- Div Arty HHC (0-1)
  - FA Battalions (0-3) (155,105)
  - FA Btrys (0-*) (Tab, MLRS, 203mm,155)
- Avn Bde HHC
  - ATK Helo Bn (0-1)
  - Assault Helo Bn (0-1)
  - Command Avn Co (0-1)
- Division Supt Com HHC (0-1)
  - Med Bn (0-1)
  - Transport Bn (0-1)
  - Maint Bn (0-1)
- Engineer Bn
- CEWI Bn
- MP Co
- CML Co
- Corps CEWI Brigade:
  - HHD: 34202L000
  - Ops Bn: 34225L000
  - MIBn (TE): 34225L000
  - AEB: 34415L200

Figure A-60. CEW1.

Level:	**Battalion**
Type:	**Airborne Inf**
TOE:	**07035L000**
ID:	**1Bn/1Bde/82ABN**

Personnel Strength	
Off	42
Enl	637
CBT Pwr Equivalent	
Major Equipment	
Tubular Launched Guided Msl_L45740	20
Night Vision Goggle: AN/PVS-7B_N05482	316
Terminal Radio-Telephone Mobile: T55957	2
Night Sight Equipment: (TOW2): N04982	20
Trk, Utility: Cargo/Troop Carrier: T61494	36
Trk, Utility: Tow Carrier: T05096	20
Radio Set AN/PRC-119: R55268	55
Trk, Cargo: 2-1/2 Ton 6x6 W/E: X40009	10
Night Vision Sight-Tracker: N23721	18
Radio Set: AN/VRC-88: R44727	26
Night Vision Sight Individual: N04732	106
Radio Set: AN/VRC-92: R45339	11
Viewer Infrared: AN/PAS-7: Y03104	15
Speech Security Equipment: TSE: S01373	117
Radio Set AN/VRC-91: R45271	11
Rifle 5.56mm M16A2: /R95035	464
Machine Gun Grenade 40mm: M92362	14
Mask Chemical Biological: M40: M12418	701
Trk, Ambulance: 2 Litter Armed: T38707	4
Tracker, Infrared Guided Msl: W80715	18
Mortar, 60mm: On Mount: M67939	6
Machine Gun 5.56mm: M09009	90
Training Set Guided Msl Sys: X04584	5
Radio Set AN/PRC-126: R55336	50
Shelter System Collective Protection: T00474	2
Radial Set: AN/PDR-75: R30925	12
Mortar 81mm Sys: M02114	4
Monitor Chemical Agent: C05701	12
Rifle, 5.56mm M4: R97234	145
Platoon Early Warning System: P06148	10
Laser Infrared Observation Set: L40063	17
Just Kit: MK-2326/VRC: J47457	24
Radio Set: AN/VRC-90: R45203	7
Camouflage Screen System: Wood: C89145	157
Computer Set Ballistics: Mortar: C60294	8
Motorcycle: 2 Wheel: 244650	15
Subunits:	
HHC	1
Rifle Company	3
Weapons Company	1

Figure A-61. Airborne infantry.

Level:	**Company**
Type:	**Airborne Inf**
TOE:	
ID:	**A Co., 1st Bn, 1st Bde, 82nd Airborne**

Personnel Strength	
Off	6
Enl	164
CBT Pwr Equivalent	
Major Equipment	
Night Vision Goggle: AN/PVS-7B: N05482	80
Trk, Utility: Cargo/Troop Carrier: T61494	6
Radio Set: AN/PRC-119: R55268	12
Trk, Cargo: 2-1/2 Ton 6x6 W/E: X40009	1
Radio Set: AN/VRC-88: R44727	5
Night Vision Sight Individual: N04732	90
Radio Set: AN/VRC-92: R45339	2
Viewer Infrared: AN/PAS-7: Y03104	2
Speech Security Equipment: TSE: S01373	22
Radio Set: AN/VRC-91: R45271	2
Rifle 5.56mm: M16A2: R95035	103
Machine Gun Grenade 40mm: M92362	4
Mash Chemical Biological: M40: M12418	175
Mortar, 60mm: On Mount: M67939	2
Machine Gun: 5.56mm: M09009	26
Radio Set: AN/PRC-126: R55336	13
Radio Set: AN/PPR-75: R30925	2
Monitor, Chemical Agent: C05701	2
Rifle, 5.56mm: M4: R97234	32
Platoon Early Warning System: P06148	3
Laser Infrared Observation Set: L40063	2
Radio Set: AN/VRC-90: R45203	2
Camouflage Screen System: Wood: C89145	24
Computer Set Ballistics: Mortar: C60294	2
Subunits	
Co. Headquarters Section	1
Wpns Plt	1
Rifle Platoons	3

Figure A-62. Airborne infantry.

Non-Military
Member of Linked Organization

Figure A-63a. Non-military attributes.

Non-Military
Request Resources Supply Resources Request Information Provide Information

Figure A-63b. Non-military methods.

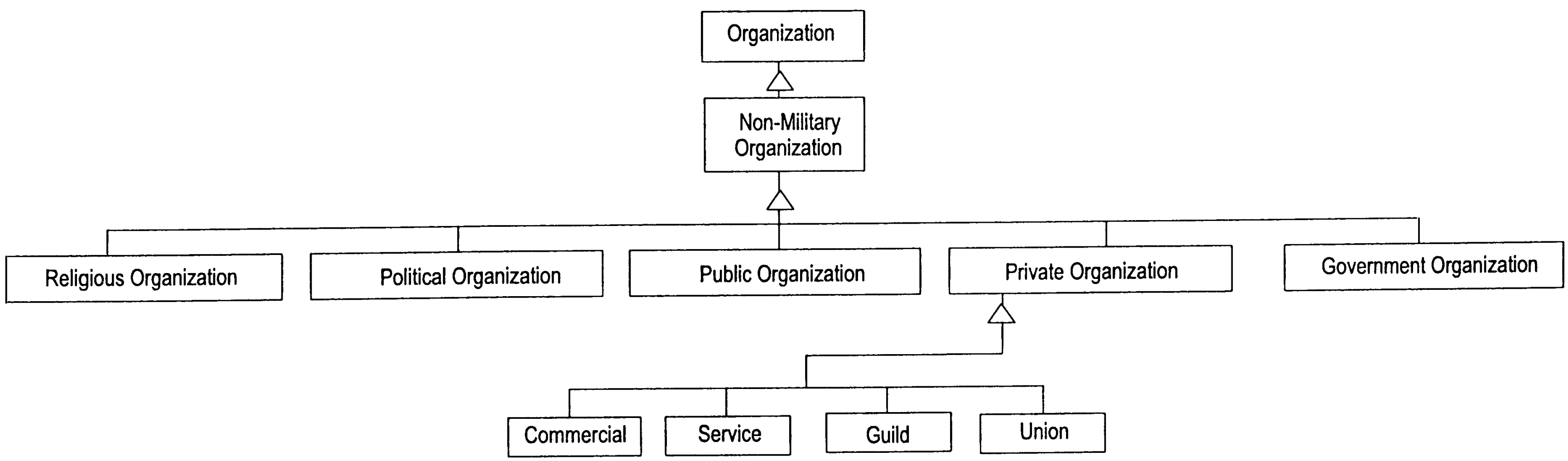


Figure A-64. Non-military organization.

Religious Organization

Mission
Type_ofReligiousOrg
Name
Person_in_charge_name
Person_in_charge_title
Successor
Structure
–Location of HQ
—Alternate HQ
–Branch Address

Figure A-64a. Non-military organization attributes.

Religious Organization

Assist Relief Services
Assist Communications with Populace
Provide Counseling Services
Provide Funeral Services

Figure A-64b. Non-military organization methods.

Political Organization

Mission
Type_ofPoliticalOrg
Name
Person_in_charge_name
Person_in_charge_title
Successor
Structure
–Location of HQ
—Alternate HQ
—Field HQ
—Permanent Address
–Branch Address

Figure A-64c. Political organization attributes.

Political Organization

Request Status
Mobilize Groups

Figure A-64d. Political organization methods.

Public Organization

Mission
Type_of_PublicOrg
Industry
Name
Union_NonUnion
Person_in_charge_name
Person_in_charge_title
Successor
Structure
–Location of HQ
—Alternate HQ
—Field HQ
—Permanent Address
—Branch Address

Figure A-64e. Public organization attributes.

Public Organization

Define Mission
Report Assets
Support Relief Operations

Figure A-64f. Public organization methods.

Private Organization
Mission Type_ofPrivateOrg Industry Name Union_NonUnion Person_in_charge_name Person_in_charge_title Successor Structure –Location of HQ —Alternate HQ —Field HQ —Permanent Address —Branch Address

Figure A-64g. Private organization attributes.

Private Organization
Report Inventory Provide Services Provide Material

Figure A-64h. Private organization methods.

Government Organization
Agency/Branch Name Address_mail Address_msg_PLAD Person_in_charge_name Person_in_charge_title Charter (function) Successor Structure –Location of HQ —Alternate HQ —Field HQ —Permanent Address —Branch Address Provide Support

Figure A-64i. Government organization attributes.

Government Organization
Provide Authorization Implement Policy Provide Direction

Figure A-64j. Government organization methods.

Crew
Number of Members Readiness Training Skill Distribution

Figure A-65a. Crew attributes.

Crew
Assess Readiness Determine Casualties Operate Equipment Request Resupply Consume Resources

Figure A-65b. Crew methods.

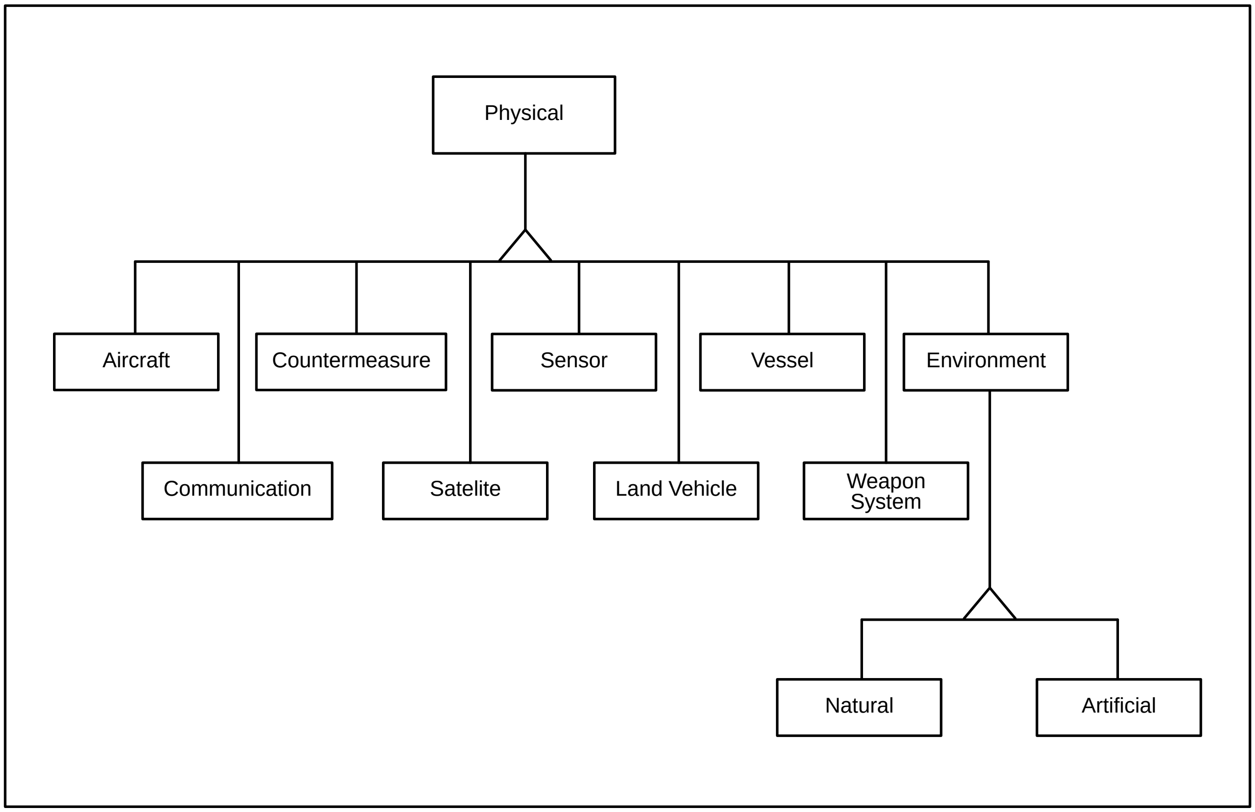


Figure A-66. Physical subtree.

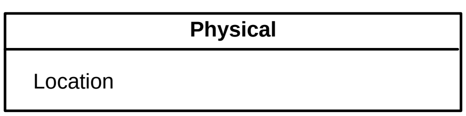


Figure A-67a. Physical attribute.

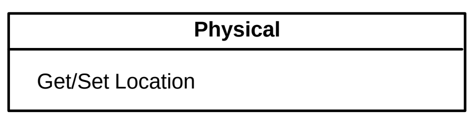


Figure A-67b. Physical method.

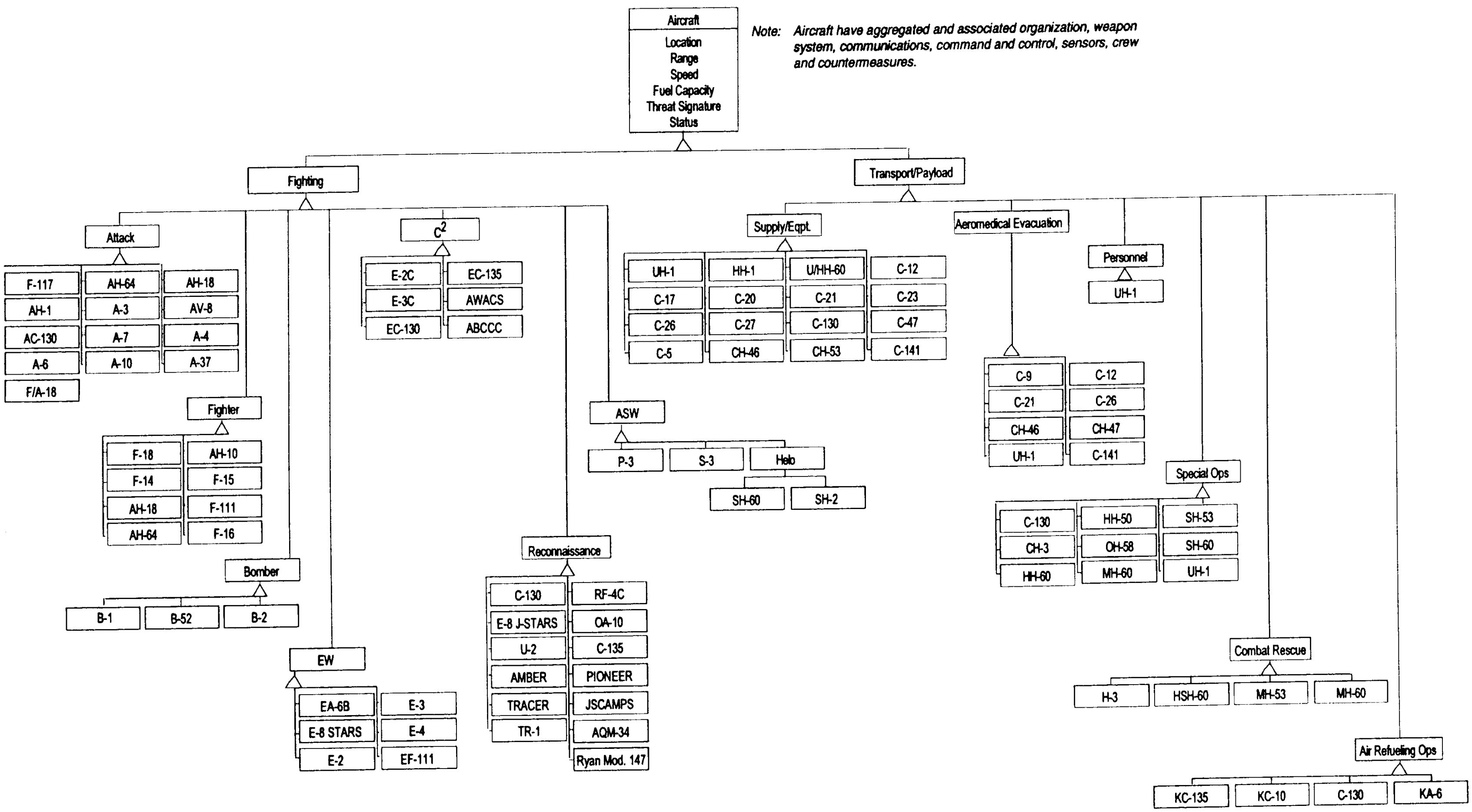


Figure A-68. Aircraft subtree.

Aircraft
Type Model Series Crew Location Unrefueled Ferry Range Range with In-Flight Refueling Max Speed–Sea Level Cruise Speed Fuel Capacity Status Threat Signature Min T-O Distance Service Ceiling Min Landing Distance Length Height Wingspan Wheelbase Max Gross T-O Weight Max Climb Rate at Sea Level Number of Engines Identification Country of Origin Country of Operation Max Hover Height Max Hover Weight Empty Weight Scheduled Maintenance Primary Configuration Code IFF Code

Figure A-69a. Aircraft attributes.

Aircraft
Change Status Change Speed Change Course Report Status Takeoff Fly Land Refuel Be Maintained Rendevous Fly in Formation

Figure A-69b. Aircraft methods.

Fighting
Max Climb Rate “g” Limits ± Aspect Ratio Max Speed at Altitude Max Range with External Tanks Combat Ceiling External Tank Restrictions Combat Air Patrol Endurance (at distance) Aiming System Electronic Countermeasures Suite Cryptographic Communications Suite Radar Warning Receiver Head Up Display—yes/no

Figure A-70a. Fighting attributes.

Fighting
Calculate Maximum Speed/Altitude Calculate Maximum Angle of Attack at Speed Evade/Avoid

Figure A-70b. Fighting methods.

Attack
Max External Stores Hi-Lo-Hi Range Bombing System Hellfire, yes/no Maverick, yes/no Sidewinder, yes/no Mk Series Bombs, yes/no Mk Series LGB, yes/no Bullpup, yes/no HARM, yes/no Rockeye, yes/no CBU59, yes/no GATOR Mines, yes/no Laser Spot Tracker, yes/no

Figure A-71a. Attack attributes.

Attack
Strafe Drop Bomb Launch Rockets

Figure A-71b. Attack methods.

Fighter
Max Combat Radius Max Radar Range Radar Discrimination at Max Rng Pulse Doppler Radar–yes/no IFF Interrogator–yes/no Internal Gun–yes/no Phoenix–yes/no Sparrow–yes/no Sidewinder–yes/no AMRAAM–yes/no

Figure A-72a. Fighter attributes.

Fighter
Strafe Shoot Missiles Engage

Figure A-72b. Fighter methods.

Bomber
Air Launch Cruise Missile–yes/no Covert Strike Radar–yes/no SRAM II Capable–yes/no Cleared for Nuclear Delivery–yes/no

Figure A-73a. Bomber attributes.

Bomber
Bomb

Figure A-73b. Bomber methods.

Electronic Warfare (EW)
Jamming Transistors Auto Detection–yes/no Auto ID–yes/no Auto Direction Finding–yes/no Coherent Countermeasures Capability–yes/no Universal Exciter Upgrade

Figure A-74a. Electronic warfare attributes.

Electronic Warfare (EW)
Detect Jam Report Identify Locate Track

Figure A-74b. Electronic warfare methods.

Command and Control (C^2)
Airborne Very Low Frequency Capable–yes/no SATCOM UNF Capable–yes/no Radar Capable–yes/no Pulse Doppler Radar–yes/no Beyond the Horizon Radar Capable–yes/no Maritime Detection Capable–yes/no HF Capable–yes/no VHF Capable–yes/no UHF Capable–yes/no

Figure A-75a. C^2 attributes.

Command and Control (C^2)
Control Assign Communicate Sends Messages Report

Figure A-75b. C^2 methods.

Reconnaissance
Pod Required–yes/no Camera Specified SLAR Capable

Figure A-76a. Reconnaissance attributes.

Reconnaissance
Take Pictures Analyze Picture Transmit

Figure A-76b. Reconnaissance methods.

ASW
Sonar Tape Recorder–yes/no Magnetic Anomaly Detector–yes/no Time-Code Generator–yes/no Sonar Tape Recorder–yes/no Set Anomaly Detector–yes/no Magnetic Compensator–yes/no 360° Radar–yes/no MK46 Torpedo–yes/no MK50 Torpedo–yes/no MK54 Depth Bomb–yes/no MK82 Bomb–yes/no MK83 Bomb–yes/no MK60 Torpedo–yes/no

Figure A-77a. ASW attributes.

ASW
Drop Sonar Buoy Drop Bomb Drop Torpedo Detect Track Identify

Figure A-77b. ASW methods.

Transport/Payload
Door Dimension Number Passengers Cargo Space–Length Cargo Space–Width Cargo Space–Height Payload at Max Fuel FAA T-O Distance FAA Landing Distance External Max. Wt. Delivery and Container Release System Aircraft Call Sign Cargo Hook Mission Radius Inflight Refueling Capability

Figure A-78a. Transport/payload attributes.

Transport/Payload
Load Unload Transport Air Drop

Figure A-78b. Transport/payload methods.

Supply/Equipment
Countermeasures Ski Equipped Pontoons Pallet Capacity Troop Capacity Vehicle Capacity Ground Proximity Extraction Capability Low Altitude Parachute Extraction System

Figure A-79a. Supply/equipment attributes.

Supply/Equipment
Air Drop (Specialized Methods as Instantiated)

Figure A-79b. Supply/equipment methods.

Aeromedical Evacuation
Number of Litters Rescue Hoist Flotation Bag Number of Attendants Cargo Door

Figure A-80a. Aeromedical evacuation attributes.

Aeromedical Evacuation
Provide Emergency Medical Care

Figure A-80b. Aeromedical evacuation methods.

Personnel
Galley Removable Seats Cargo Area Parachute Jump Door

Figure A-81a. Personnel attributes.

Personnel
Deploy Personnel

Figure A-81b. Personnel methods.

Special Ops
Nose Radome with Retrieval Yoke Terrain Following Radar Secure Voice Inertial Navigation System Refueling Probe Container Release System IR Detection System 105 mm Howitzer 40 mm Cannon 20 mm Cannon

Figure A-82a. Special ops attributes.

Special Ops
Detect Fire Identify Jam Report Identify Locate Track

Figure A-82b. Special ops methods.

Combat Rescue

Rescue Hoist
Retrieval Yoke
Sea Search Radar
Rescue Kit Drop Platform
Camera with Data Annotation
IR Scanner
Aerial Recovery Package

Figure A-83a. Combat rescue attributes.

Combat Rescue

Lift
Locate
Extract

Figure A-83b. Combat rescue methods.

Air Refueling Ops

Max Fuel Capacity with Auxiliary Tank
Transfer Flow Rate
Helicopter Capable
Pylon Fuel Tank
Extended Range
Max Fuel to Offload at Mission Radius

Figure A-84a. Air refueling ops attributes.

Air Refueling Ops

Provide Fuel
Rendezvous

Figure A-84b. Air refueling ops methods.

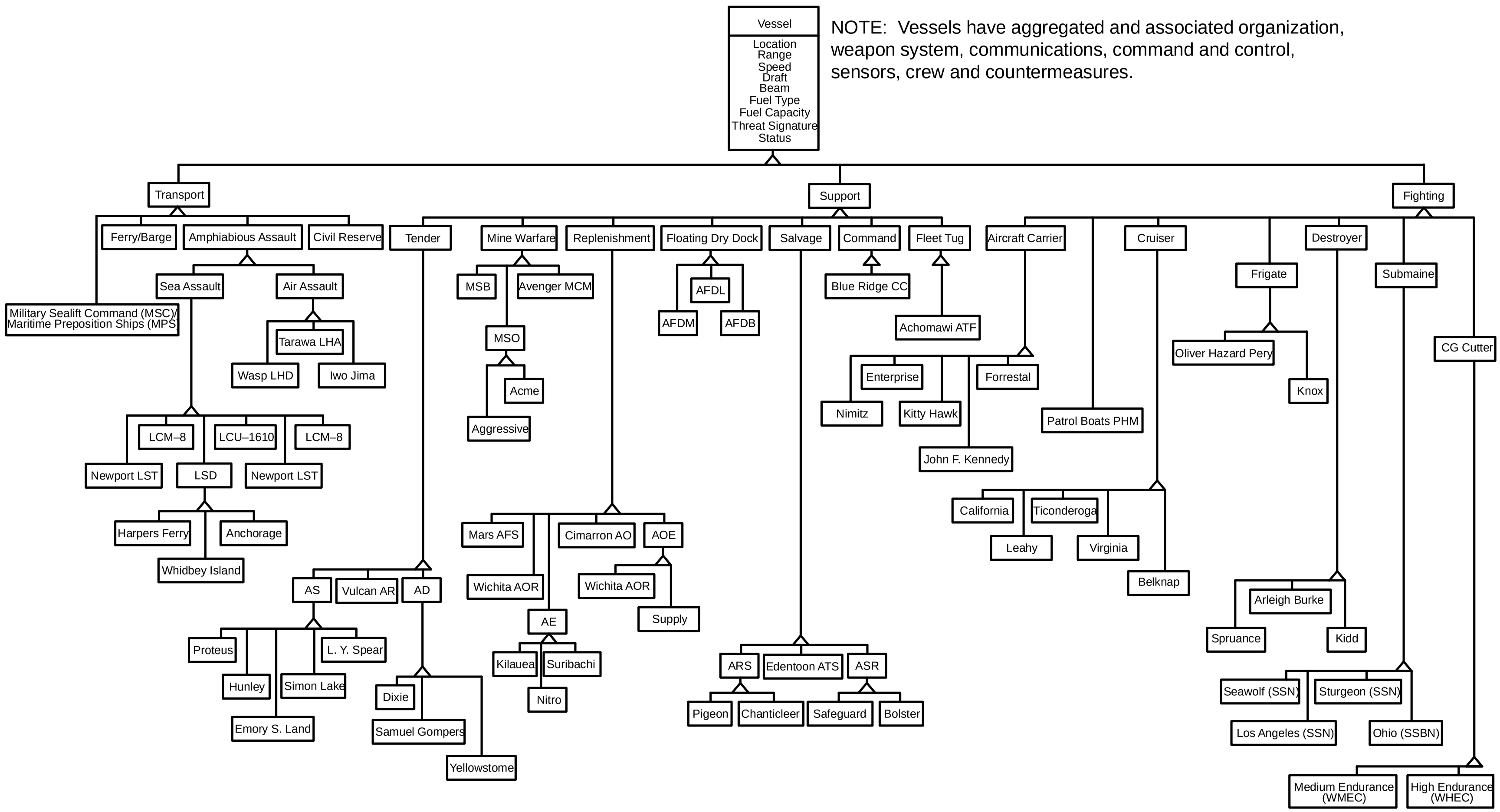


Figure A-85. Vessel subtree.

Vessel
Status Beam Fuel Capacity Threat Signature Type Class Displacement Dimensions Draft Hull Dynamics Main Propulsion Type Number of Main Propulsion Plants Aux Propulsion Type Number of Aux Propulsion Plants Screw Type Number of Screws Speed Acceleration Deceleration Range Endurance Pitch Roll Yaw Turning Radius Turn Rate Reserve Buoyancy Fuel Type Fuel Consumption Rate Stores Capacity Stores Consumption Rate Water Storage Capacity Water Making Capacity (rate) Complement Communications Sensors Navigation/GPS Fire Control Systems Weapons Countermeasures Radiated Noise Radar Cross Section Damage Vulnerabilities

Figure A-86a. Vessel attributes.

Vessel
Change Status Change Course Dock Load Unload Be Maintained Change Speed Take on Fuel Consume Supplies Rendezvous Move in Convoy

Figure A-86b. Vessel methods.

Transport
Cargo Capacity Military Lift Capacity

Figure A-87a. Transport attributes.

Transport
Load Unload Transport

Figure A-87b. Transport methods.

Military Sealift Command (MSC)/ Maritime Pre-Positioned Ships (MPS)
Aircraft Capability Container Capacity Crane Capacity Medical Facilities Cargo Loading Method

Figure A-88a. Military Sealift Command (MSC)/Maritime Pre-Positioned Ships (MPS) attributes.

Military Sealift Command (MSC)/ Maritime Pre-Positioned Ships (MPS)
Store Equipment Maintain Equipment Provide Equipment

Figure A-88b. Military Sealift Command (MSC)/Maritime Pre-Positioned Ships (MPS) methods.

Ferry/Barge
Lifting Capacity Load Method

Figure A-89a. Ferry/barge attributes.

Ferry/Barge
Objects of this class will specialize inherited methods

Figure A-89b. Ferry/barge methods.

Amphibious Assault
Flight Deck Aircraft Embarked Command/Control

Figure A-90a. Amphibious assault attributes.

Amphibious Assault
Launch Aircraft Recover Aircraft Control Aircraft Launch Small Boats Recover Small Boats

Figure A-90b. Amphibious assault methods.

Air Assault
Fixed Wing Aircraft Embarked Aircraft Launch Envelope

Figure A-91a. Air assault attributes.

Air Assault
Launch Aircraft Recover Aircraft

Figure A-91b. Air assault methods.

Sea Assault
Amphibious Craft Capacity Launch Envelopes

Figure A-92a. Sea assault attributes.

Sea Assault
Launch Amphibious Craft Recover Amphibious Craft

Figure A-92b. Sea assault methods.

Civil Reserve
Lifting Capacity Load Method

Figure A-93a. Civil reserve attributes.

Civil Reserve
Objects of this class will specialize inherited methods

Figure A-93b. Civil reserve methods.

Tender
Repair Facilities/Equipment
Diving Support Capability
Crane Capacity
Medical Facilities
Recompression Chamber
Deep Submergece Capability

Figure A-94a. Tender attributes.

Tender
Perform Maintenance
Rendezvous
Perform Repair

Figure A-94b. Tender methods.

Mine Warfare
Aircraft Embarked
Cargo Capacity

Figure A-95a. Mine warfare attributes.

Mine Warfare
Deploy Mines
Detect Mines
Clear Minefields

Figure A-95b. Mine warfare methods.

Replenishment
Cargo Type
Replenishment Stations
Cargo Capacity
Aircraft Embarked

Figure A-96a. Replenishment attributes.

Replenishment
Replenish
Rendezvous

Figure A-96b. Replenishment methods.

Floating Drydock
Load Capacity
Lifting Capacity
Construction Material

Figure A-97a. Floating drydock attributes.

Floating Drydock
Perform Maintenance
Perform Repairs

Figure A-97b. Floating drydock methods.

Salvage
Diving Support Capability
Recompression
Lifting Capacity

Figure A-98a. Salvage attributes.

Salvage
Locate
Recover
Tow

Figure A-98b. Salvage methods.

Command
Command/Control

Figure A-99a. Command attributes.

Command
Objects of this class will specialize inherited methods

Figure A-99b. Command methods.

Fleet Tug
Tow Capacity Pump Capacity

Figure A-100a. Fleet tug attributes.

Fleet Tug
Push Tow Pump

Figure A-100b. Fleet tug methods.

Fighting
Combat Data Systems Command/Control

Figure A-101a. Fighting attributes.

Fighting
Intercepts Locate Pursue Attack Defend Engage

Figure A-101b. Fighting methods.

Aircraft Carrier
Type Flight Deck Size Number of Fixed Wing Aircraft Number of Rotary Wing Aircraft Refueling Capabilities Aircraft Launch Envelope Medical Facilities

Figure A-102a. Aircraft carrier attributes.

Aircraft Carrier
Launch Aircraft Remove Aircraft

Figure A-102b. Aircraft carrier methods.

Patrol Boats PHM
Type Special Forces Complement Diving Support Facilties

Figure A-103a. Patrol boats PHM attributes.

Patrol Boats PHM
Detect Intercept

Figure A-103b. Patrol boats PHM methods.

Cruiser
Type Phased Array ASW Aircraft Embarked

Figure A-104a. Cruiser attributes.

Cruiser
Launch Missiles

Figure A-104b. Cruiser Methods.

Frigate
Type Sonar–A Sonar–P ASW Aircraft Embarked

Figure A-105a. Frigate attributes.

Frigate
Launch Missiles

Figure A-105b. Frigate methods.

Destroyer
Type Phased Array ASW Aircraft Embarked

Figure A-106a. Destroyer attributes.

Destroyer
Provide Naval Gunfire Support

Figure A-106b. Destroyer methods.

Submarine
Type Ballistic Missiles Crush Depth Design Depth Test Depth Periscope Depth Speed (dived) Speed (surfaced) Endurance (submerged)

Figure A-107a. Submarine attributes.

Submarine
Submerge Fire Torpedo Fire Missile Surface

Figure A-107b. Submarine methods.

CG Cutter
Type NBC Aircraft Embarked

Figure A-108a. CG Cutter attributes.

CG Cutter
Search Locate Rescue Supply

Figure A-108b. CG Cutter methods.

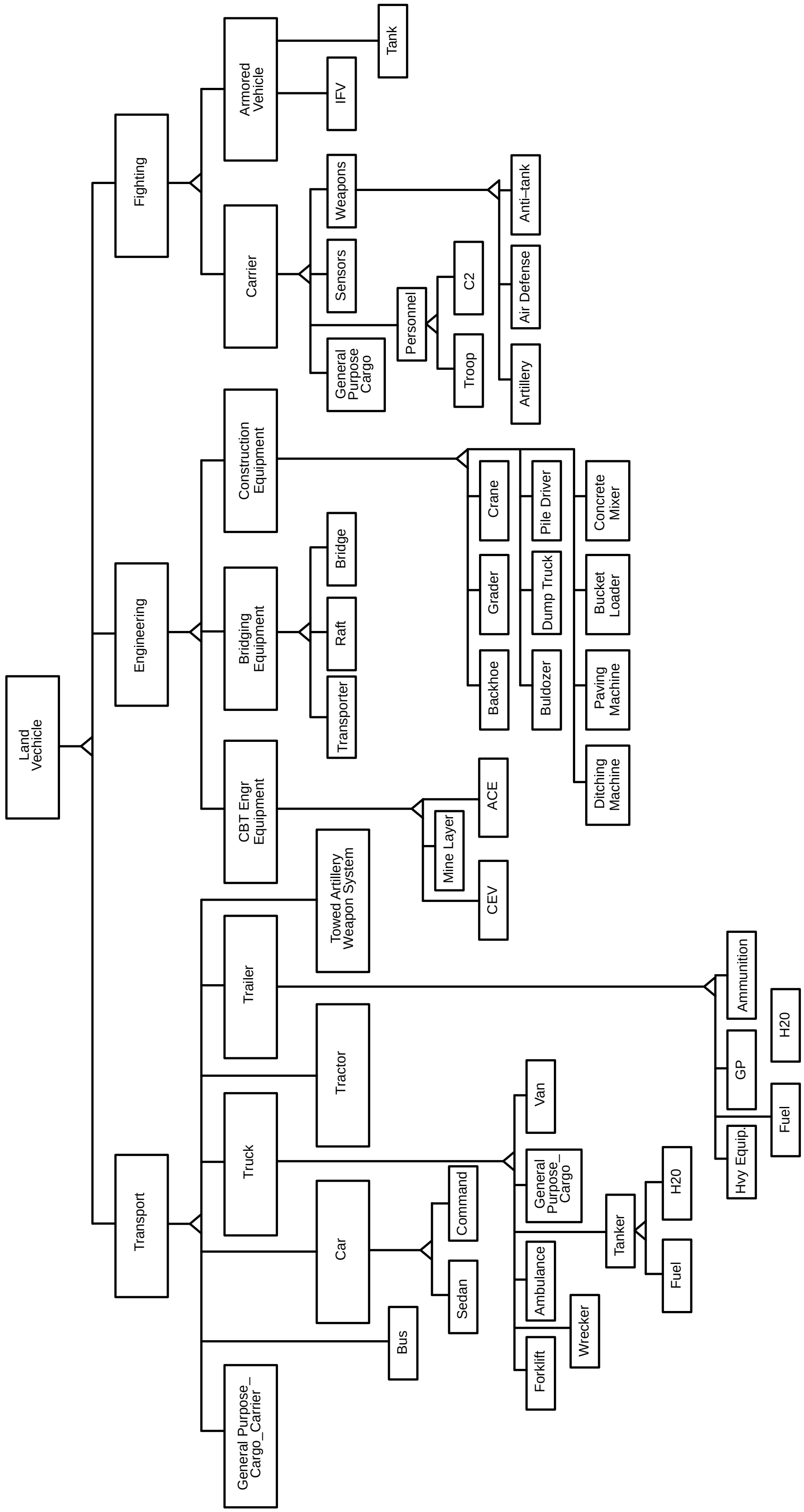


Figure A-109. Land vehicle subtree.

Land Vehicle

Platform_LandVehicle
Identity
Country_Origin
Country_Operation
Make
Model
SerialNumber_Vehicle
Color
LIN#
CamouflageSchema
BumperIDNumber
SerialNumber_Convoy
Status
Location
Destination
Range_Average
Range_Extended
TopSpeed
PlanningSpeed
ActualSpeed
PlanningDirection
ActualDirection
Type_Armor
Location_Armor
Weapon_Type
MobilitySystem_Type
Axle_Number
Axle_Location
Wheels_Number
Wheels_Location
BogieWheels_Number
BogieWheels_Location
TrailingWheels_Number
TrailingWheels_Location
GuideWheels_Number
GuideWheels_Location
DriveWheels_Number
DriveWheels_Location
Chassis_Articulation
Crew_Type
Crew_Number
Fuel_Type
Fuel_Capacity
Fuel_ConsumptionRate
Body_Length
Body_Width
Body_Height
GroundClearance_Minimum
GroundClearance_Maximum
Tire_Width
Tire_Type
Tire_Size
Track_LinkSize
Track_Type
Track_LinkWidth
Track_LengthOnGround
Weight_Unloaded
Weight_Combat
GroundPressure
Vehicle_Cube
Max_RoadSpeed
Max_CrossCountrySpeed
Max_FordingDepth_Unprepared
Max_FordingDepth_Prepared
Type_FordingEquipment
Max_VerticalObstacleHeight
Max_TrenchWidth
Location_CrewCompartment
Engine_Location
Engine_Type
Engine_NumberCylinders
Engine_Horsepower
Ratio_HorsepowerToWeight
Transmission_Type
Steering_Type
Driver_Location
Suspension_Type
Navigation_Type
VisionSystem_Type
TurningRadius
Acceleration
Amphibious
AmphibiousDrive_Type
ElectricalSystem_Voltage
Communications_System
Toolkit
Spare_MobilityGear
MaxPercent_Slope
MaxPercent_Gradient
Associated_Trailer
RemoteGuidanceSys
Photo
Manual_Operating
Manual_Maintenance
Manual_TacticalEquipment
NBCSys
Type_VisMod
Type_VisID
Type_IFF
Type_CamouflageSchema
CenterOfGravity_Empty
CenterOfGravity_Loaded
TowPoint_Type
TowPoint_Capacity
TowPoint_Location

Figure A-110a. Land vehicle attributes.

Land Vehicle

Load
Move
Unload
Consume
Determine Status
Rendezvous
Move in Convoy

Figure A-110b. Land vehicle methods.

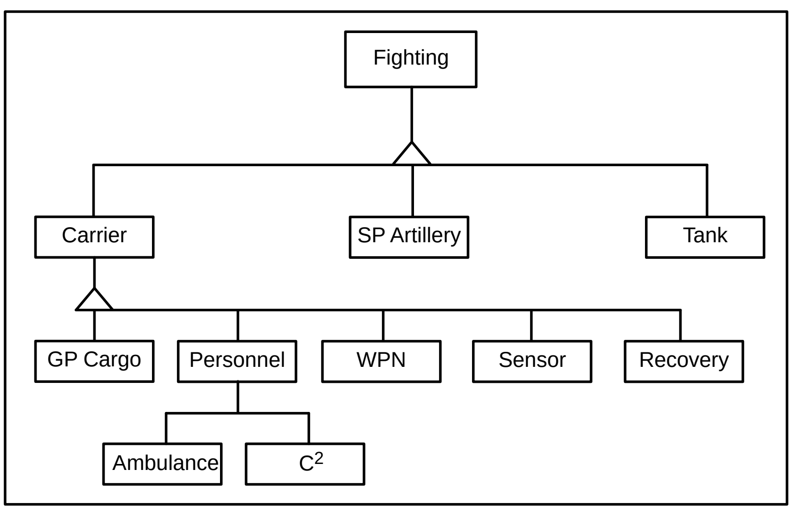


Figure A-111. Fighting.

Land Vehicle-Fighting

Type_Configuration
MissionArea
Type_WpnsSystem_Main
Purpose_WpnsSystem_Main
MaxElevation_WpnsSystem_Main
MinDepression_WpnsSystem_Main
Traverse_WpnsSystem_Main
PositionOnVehicle_WpnsSystem_Main
TypeAmmunition_WpnsSystem_Main
  APFSDS
  HEAT-FS
  HED-T
  HE-FRAG
  Smoke
QtyAmmunition_WpnsSystem_Main
Type_WpnsSystem_Secondary
Purpose_WpnsSystem_Secondary
MaxElevation_WpnsSystem_Secondary
MinDepression_WpnsSystem_Secondary
Traverse_WpnsSystem_Secondary
PositionOnVehicle_WpnsSystem_Secondary
TypeAmmunition_WpnsSystem_Secondary
QtyAmmunition_WpnsSystem_Secondary
Type_WpnsSystem_Tertiary
Purpose_WpnsSystem_Tertiary
Max_Elev_WpnsSystem_Tertiary
Min_Depression_WpnsSystem_Tertiary
Traverse_WpnsSystem_Tertiary
PositionOnVehicle_WpnsSystem_Tertiary
Type_Ammunition_WpnsSystem_Tertiary
Qty_Ammunition_WpnsSystem_Tertiary
SmokeLaying
Thickness_Armor_FrontUpper
Thickness_Armor_FrontLower
Thickness_Armor_SideUpper
Thickness_Armor_SideLower
Thickness_Armor_RearUpper
Thickness_Armor_RearLower
Thickness_Armor_TopTurret
Thickness_Armor_TopHull
Thickness_Armor_BellyFront
Thickness_Armor_BellyRear
Thickness_Armor_TurretFront
Thickness_Armor_TurretSide
Type_CollectiveNBCProtectionSystem
FireControlSystem
FireSuppressionSystem
FireControlSystemController
Glacis_Front_Upper
Glacis_Front_Lower
Glacis_Side_Upper
Glacis_Side_Lower
Glacis_Rear_Upper
Glacis_Rear_Lower

Figure A-112a. Land vehicle-fighting attributes.

Land Vehicle-Fighting
Targets Shoots Intercepts Occupy Battle Position

Figure A-112a. Land vehicle-fighting attributes.

Carrier
Type_Carrier Units_Carried Item_Carried

Figure A-113a. Carrier attributes.

Carrier
Objects of this class will specialize   inherited methods

Figure A-113b. Carrier methods.

GP Cargo
Type_Bed Length_Bed Width_Bed Height_Bed Current_Load CargoDoor_Number CargoDoor_Width CargoDoor_Height MaxCargoWeight

Figure A-114a. GP cargo attributes.

GP Cargo
Objects of this class will specialize inherited methods

Figure A-114b. GP cargo methods.

Personnel
TroopCompartment_Size TroopCompartment_Exposure TroopCompartment_AccessDoors Size_TroopCompartment_Access Doors TroopCompartmentObservationPorts TroopCompartmentFiringPorts MaxTroopCapacity SpecializedPurpose

Figure A-115a. Personnel attributes.

Personnel
Objects of this class will specialize inherited methods

Figure A-115b. Personnel methods.

Weapon
Type_WpnSystem Use_WpnSystem Housing_WpnSystem TargetAcquisition TargetAcquisitionSystem

Figure A-116a. Weapon attributes.

Weapon
Locates Targets Tracks

Figure A-116b. Weapon methods.

Sensor
Type_Sensor Use_Sensor Housing_Sensor

Figure A-117a. Sensor attributes.

Sensor
Objects of this class will specialize inherited methods

Figure A-117b. Sensor methods.

Recovery
Capacity_FreewheelTowing Capacity_ShedTowing Type_TowPoint Capacity_TowPoint Location_TowPoint Type_CraneSystem Location_CraneSystem Capacity_CraneSystem MaxHeight_CraneSystem Type_Winch Location_Winch Capacity_Winch Type_Blade Location_Blade

Figure A-118a. Recovery attributes.

Recovery
Lift Tow Push Repair

Figure A-118b. Recovery methods.

SP Artillery
Type_Carriage Type_MainWpnSystem Type_Stabilization Type_RecoilSystem Type_LoadingSystem Type_Supporting_Vehicle CombinedLength_TravelLock CombinedLength_Operational

Figure A-119a. SP artillery attributes.

SP Artillery
Objects of this class will specialize inherited methods

Figure A-119b. SP artillery methods.

Tank
Type_Hull Location_MainGun_AmmoStowage Type_Loader

Figure A-120a. Tank attributes.

Tank
Tracks Calculates Range Selects Ordnance Load Ordnance

Figure A-120b. Tank methods.

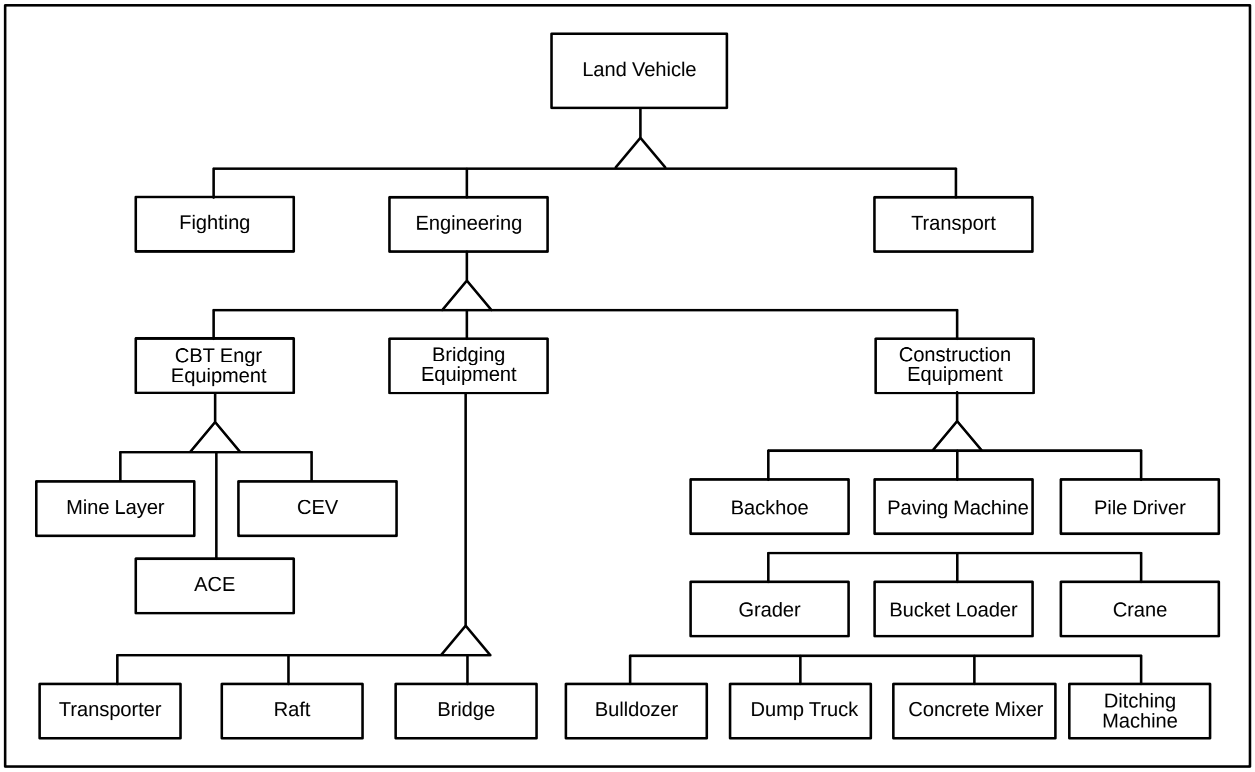


Figure A-121. Engineering.

Engineering Equipment
Roadworthy MissionArea MissionArea_Services

Figure A-122a. Engineering equipment attributes.

Engineering Equipment
Make Destroy Repair

Figure A-122b. Engineering equipment methods.

Combat Engineering Equipment
Armored

Figure A-123a. Combat engineering equipment attributes.

Combat Engineering Equipment
Objects of this class will specialize inherited methods

Figure A-123b. Combat engineering equipment methods.

Mine Layer
Conveyor Furrower Scraper

Figure A-123c. Mine layer attributes.

Mine Layer
Emplaces Mines Digs Furrow Arms Mines Dispenses Mines Creates Minefields

Figure A-123d. Mine layer methods.

ACE
Blade Crane Plow Launcher

Figure A-123e. ACE attributes.

ACE
Plows Lifts Launches Breaches Minefields Drags

Figure A-123f. ACE methods.

CEV
152 mm Gun Turret Blade

Figure A-123g. CEV attributes.

CEV
Plows Tows Drags Launches

Figure A-123h. CEV methods.

Bridging Equipment
Positionability Associated_Positioning_Equipment Combat_Environment Recovery_Method Associated_Recovery_Equipment

Figure A-124a. Bridging equipment attributes.

Bridging Equipment
Objects of this class will specialize inherited methods

Figure A-124b. Bridging equipment methods.

Transporter
Associated_Bridge/RaftSys Launch/Emplacement_Speed Launch/Emplacement_Method

Figure A-125a. Transporter attributes.

Transporter
Objects of this class will specialize inherited methods

Figure A-125b. Transporter methods.

Raft	Raft
MethodEmployment FloatBay_Width FloatBay_RoadwayWidth FloatBay_Length FloatBay_LiftCapacity AssembleDraft_Capacity EndBay_Length EndBay_NumberRequired EndBay_NumberAvailable AssembleDraft_Configuration Propulsion Associated_PropulsionSystem MaxGradient_Nearshore MaxGradient_Farshore MinDepth_Nearshore MinDepth_Farshore MaxSpeed_Current MaxSpeed_Raft AssembledBridge_Capacity AssembledBridge_Configuration	Float Attach Propel

Figure A-126a. Raft attributes.

Figure A-126b. Raft methods.

Bridge	Bridge
Configuration SpanSection_Width SpanSection_RoadwayWidth SpanSection_Length SpanSection_LiftCapacity RampSection_Length RampSection_NumberRequired AssembledBridge_Length BridgeCapacity BridgeConfiguration Direction_DedicatedTraffic MaxGradient_AccessBank MaxGradient_EgressBank MaxDepth_Obstacle ObstacleBottom_Composition MaxCurrent_WaterObstacle	Emplace Self (Yes/No)

Figure A-127a. Bridge attributes.

Figure A-127b. Bridge methods.

Construction Equipment	Construction Equipment
MissionArea_Planning Capacity	Objects of this class will specialize inherited methods.

Figure A-128a. Construction equipment attributes.

Figure A-128b. Construction equipment methods.

Backhoe
MaxCapacity_Bucket_Cube MaxCapacity_Bucket_Weight Bucket_Width Bucket_Depth Operating_Speed

Figure A-129a. Backhoe attributes.

Backhoe
Dig

Figure A-129b. Backhoe methods.

Paving Machine
Pavement_Width Pavement_Thickness Pavement_Material Operating_Speed Pavement_Material_ComsumptionRate

Figure A-130a. Paving machine attributes.

Paving Machine
Pave Consume Paving Material

Figure A-130b. Paving machine methods.

Pile Driver
Driver_Height Driver_Weight Driver_Drop Driver_GuideCircumference MaxLength_Pilings MaxCircumference_Pilings MinLength_Pilings MinCircumference_Pilings MaxHeight_Pilings MinHeight_Pilings

Figure A-131a. Pile driver attributes.

Pile Driver
Drive Piles Consumes Piles

Figure A-131b. Pile driver methods.

Grader
MaxCapacity_Bucket_Cube Width_Bucket MaxDepth_Bucket OperatingDepth_Bucket

Figure A-132a. Grader attributes.

Grader
Grade Level Scrape

Figure A-132b. Grader methods.

Bucket Loader
MaxCapacity_Bucket_Cube MaxCapacity_Bucket_Weight Width_Bucket MaxDepth_Bucket OperatingDepth_Bucket LiftHeight_Bucket

Figure A-133a. Bucket loader attributes.

Bucket Loader
Fills Move Material Lift Material Load Material

Figure A-133b. Bucket loader methods.

Crane
Max_Capacity_Bucket_Cube Max_OperatingDepth Max_OperatingHeight Max_WeightLifted MovementRange

Figure A-134a. Crane attributes.

Crane
Lift Move

Figure A-134b. Crane methods.

Bulldozer
MaxCapacity_Blade_Cube MaxCapacity_Blade_Weight Width_Blade MaxDepth_Blade OperatingDepth_Blade LiftHeight_Blade

Figure A-135a. Bulldozer attributes.

Bulldozer
Move Material

Figure A-135b. Bulldozer methods.

Dumptruck
MaxCapacity_Cube MaxCapacity_Weight Dump_Type

Figure A-136a. Dumptruck attributes.

Dumptruck
Moves Material Dumps Material

Figure A-136b. Dumptruck methods.

Concrete Mixer
Capacity_Cube

Figure A-137a. Concrete mixer attributes.

Concrete Mixer
Mix Concrete Consumes Material

Figure A-137b. Concrete mixer methods.

Ditching Machine
Cut_Width Cut_Depth Ditching_Speed

Figure A-138a. Ditching machine attributes.

Ditching Machine
Dig Ditch

Figure A-138b. Ditching machine methods.

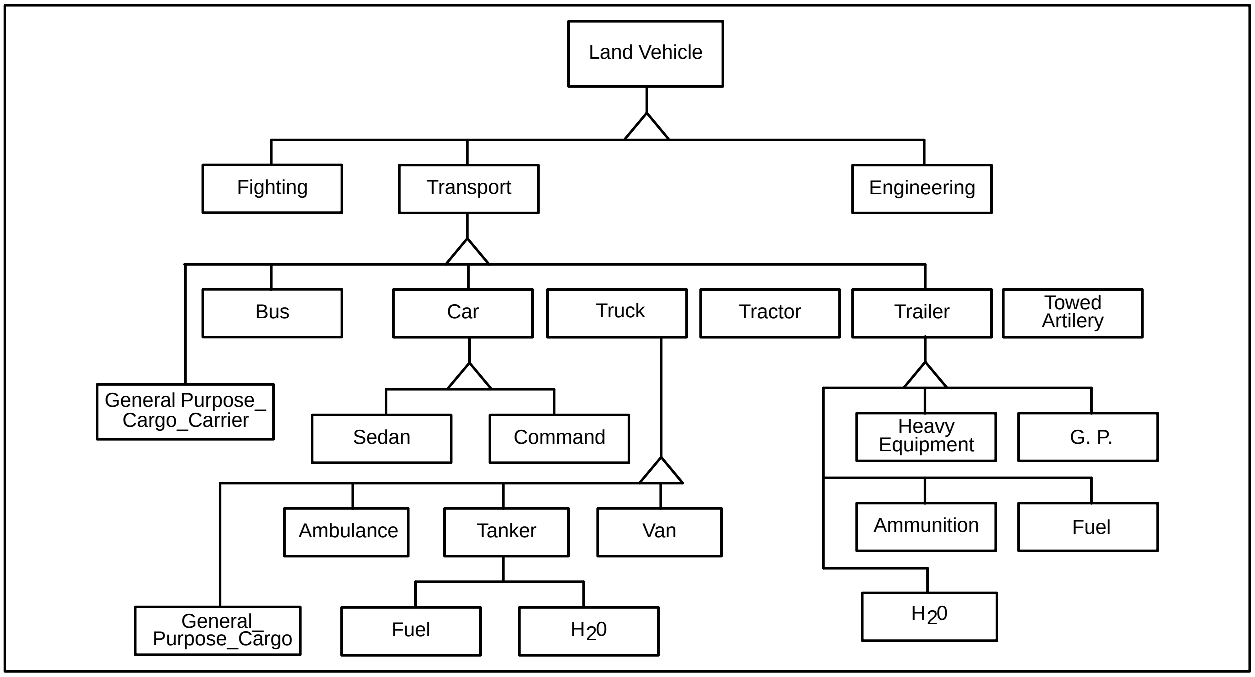


Figure A-139. Transport.

Transport
Type_Cab Location_Cab

Figure A-140a. Transport attributes.

Transport
Run Route

Figure A-140b. Transport methods.

CP Cargo Carrier
Location_Steering Location_CargoArea Type_CargoArea Cover_CargoArea Associated_ShelterSystem IntendedCargo_Type ActualCargo_Type MaxQuantity_Cargo ActualQuantity_Cargo MaxWeight_Cargo ActualWeight_Cargo MaxWidth_Cargo ActualWidth_Cargo MaxHeight_Cargo ActualHeight_Cargo MaxLength_Cargo ActualLength_Cargo Height_CargoB ed Number_AccessDoor Location_AccessDoor Width_AccessDoor Height_AccessDoor

Figure A-141a. GP cargo carrier attributes.

CP Cargo Carrier
Objects of this class will specialize inherited methods.

Figure A-141b. GP cargo carrier methods.

Bus
Location_Steering MaxNumber_Passengers ActualNumber_Passengers Number_AccessDoor Location_AccessDoor Width_AccessDoor Height_AccessDoor Number_EmergencyDoor Number_Window Associated_Equipment

Figure A-142a. Bus attributes.

Bus
Objects of this class will specialize inherited methods.

Figure A-142b. Bus methods.

Car
Location_Steering Car_Type MaxNumber_Passengers ActualNumber_Passengers Intended_Passengers Actual_Passengers Number_Door Number_Window Associated_Equipment

Figure A-143a. Car attributes.

Car
Objects of this class will specialize inherited methods.

Figure A-143b. Car methods.

Truck
Location_Steering Location_CargoArea Type_CargoArea CargoArea_Cover Associated_ShelterSystem IntendedCargo_Type ActualCargo_Type MaxQuantity_Cargo ActualQuantity_Cargo MaxWeight_Cargo ActualWeight_Cargo MaxWidth_Cargo ActualWidth_Cargo MaxHeight_Cargo ActualHeight_Cargo MaxLength_Cargo ActualLength_Cargo Height_CargoBed Number_AccessDoor Location_AccessDoor Width_AccessDoor Height_AccessDoor Associated_Trailer

Figure A-144a. Truck attributes.

Truck
Objects of this class will specialize inherited methods.

Figure A-144b. Truck methods.

GP Cargo
Location_Steering

Figure A-145a. GP cargo attributes.

GP Cargo
Objects of this class will specialize inherited methods.

Figure A-145b. GP cargo methods.

Ambulance
Location_Steering Capacity_Litters Actual_Litters Associated_MedicalTechnician Associated_EMSEquipment EmergencyMarkings

Figure A-146a. Ambulance attributes.

Ambulance
Objects of this class will specialize inherited methods.

Figure A-146b. Ambulance methods.

Tanker
Location_Steering PriorContamination_Status PriorContamination_Type CargoCompatibility Location_Pump Capacity_Pump Number_Spigot Location_Spigot Capacity_Spigot CombinedCapacity_Spigot Number_ServiceHatch Size_ServiceHatch Length_Associated_Hose Diameter_Associated_Hose Filltime_Minimum Dumptime_Minimum Filltime_Actual Dumptime_Actual

Figure A-147a. Tanker attributes.

Tanker
Objects of this class will specialize inherited methods.

Figure A-147b. Tanker methods.

Van
Location_Steering MaxNumber_Passengers ActualNumber_Passengers Number_Door Number_EmergencyDoor Number_Window CargoArea_Size IntendedCargo_Type ActualCargo_Type MaxQuantity_Cargo ActualQuantity_Cargo MaxWeight_Cargo ActualWeight_Cargo MaxWidth_Cargo ActualWidth_Cargo MaxHeight_Cargo ActualHeight_Cargo MaxLength_Cargo ActualLength_Cargo

Figure A-148a. Van attributes.

Van
Objects of this class will specialize inherited methods.

Figure A-148b. Van methods.

Tractor
TrailerCoupling_Type Associated_Trailer_Type Associated_Trailer_Actual MaxCapacity_Towing Number_Door Width_Door Height_Door

Figure A-149a. Tractor attributes.

Tractor
Objects of this class will specialize inherited methods.

Figure A-149b. Tractor methods.

Trailer
TrailerCoupling_Type Associated_Primemover_Type Associated_Primemover_Actual Location_CargoArea Type_CargoArea CargoArea_Cover Associated_ShelterSystem IntendedCargo_Type MaxQuantity_Cargo ActualQuantity_Cargo MaxWeight_Cargo ActualWeight_Cargo MaxWidth_Cargo ActualWidth_Cargo MaxHeight_Cargo ActualHeight_Cargo MaxLength_Cargo ActualLength_Cargo Height_CargoBed Number_Door Location_Door Width_Door Height_Door

Figure A-150a. Trailer attributes.

Trailer
Objects of this class will specialize inherited methods.

Figure A-150b. Trailer methods.

Towed Weapon System
TrailerCoupling_Type Associated_Primemover_Type Associated_Primemover_Actual Associated_WeaponSystem

Figure A-151a. Towed weapon system attributes.

Towed Weapon System
Objects of this class will specialize inherited methods.

Figure A-151b. Towed weapon system methods.

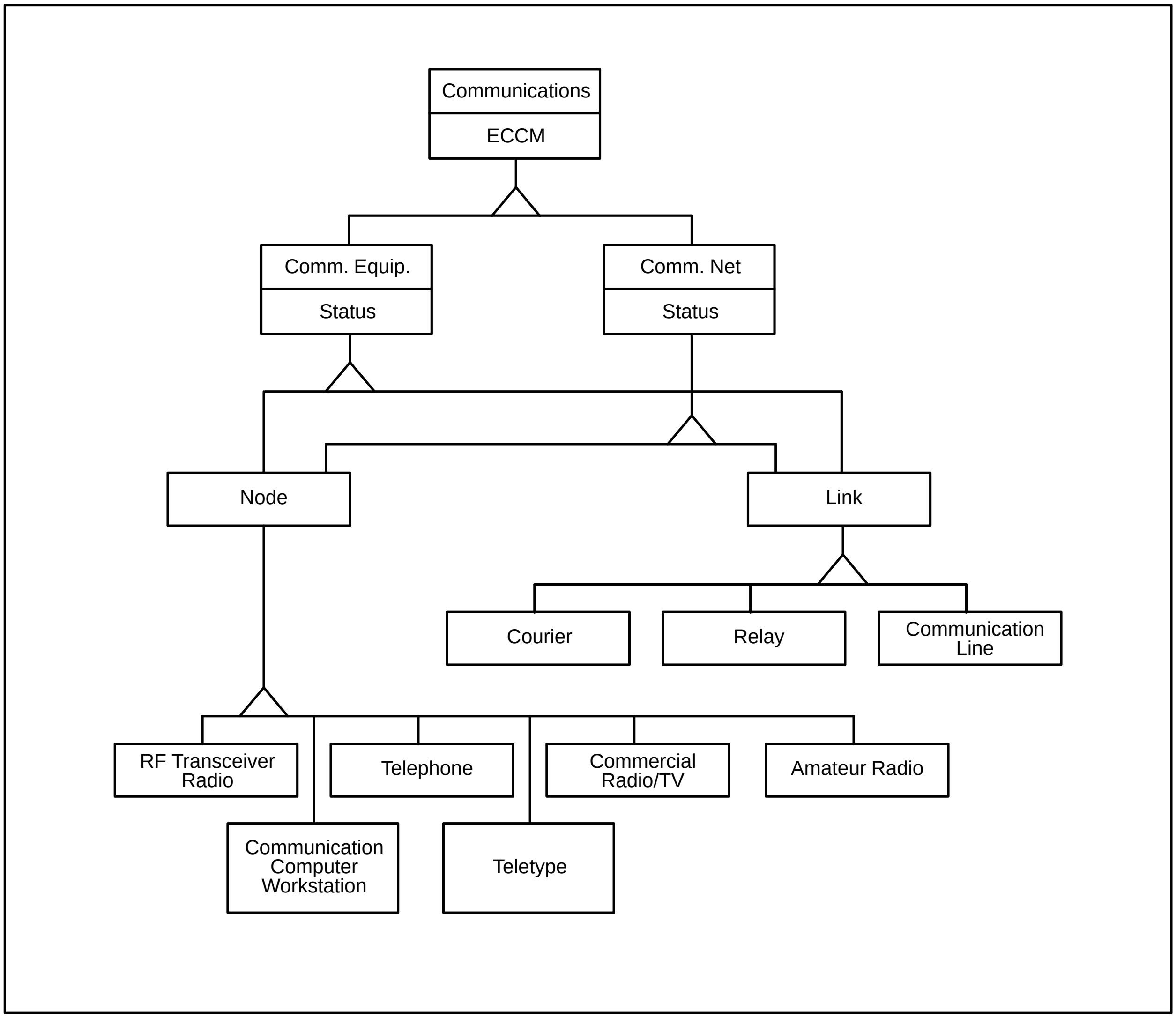


Figure A-152. Communications subtree.

Communications
ECCM Frequency Classification Bandwidth Spread Spectrum Frequency Hopping Encryption Transmission Encryption Message Product

Figure A-153a. Communications attributes.

Communications
Carries Information

Figure A-153b. Communications methods.

Communication Equipment

Status
Location
Method of Transmission:
  Voice
  FSK
  Optical
  Mechanical
Mode of Transmission:
  Duplex
  Half duplex
  Simplex
Security

Figure A-154a. Communication equipment attributes.

Communication Equipment
Send Receive Converts Deconverts Encrypt Decrypt

Figure A-154b. Communication equipment methods.

Communication Network

State of Connectivity
Area Boundary
Security
Mode of Connectivity
  RF
  Hardwire
  Fiber Optic
Line of Sight
Over the Horizon

Figure A-155a. Communication network attributes.

Communication Network
Connects Subscribers Relays

Figure A-155b. Communication network methods.

Node
Location Status Satellite Communications Transmitter Receiver

Figure A-156a. Node attributes.

Node
Objects of this class will specialize inherited methods.

Figure A-156b. Node methods.

RF Transceiver Radio

Location
Status
Portability
Frequency
Equipment Type:
  UHF
  VHF
  SHF
Antenna Type
Antenna Height

Figure A-157a. RF transceiver radio attributes.

RF Transceiver Radio
Objects of this class will specialize inherited methods.

Figure A-157b. RF transceiver radio methods.

Telephone
Fixed Mobile Portable Parkhill

Figure A-158a. Telephone attributes.

Telephone
Ring

Figure A-158b. Telephone methods.

Commercial Radio/TV
Geographic Location Call Sign Channel Number Frequency Satellite Link

Figure A-159a. Commercial radioTV attributes.

Commercial Radio/TV
Objects of this class will specialize inherited methods.

Figure A-159b. Commercial radioTV methods.

Amateur Radio
Geographic Location Antenna Height Frequency

Figure A-160a. Amateur radio attributes.

Amateur Radio
Objects of this class will specialize inherited methods.

Figure A-160b. Amateur radio methods.

Communication Computer Workstation
Name/Designator Storage Capacity CPU Type CPU Frequency Monitor Type: Color Monochrome Monitor Screen Size Portability

Figure A-161a. Communication computer workstation attributes.

Communication Computer Workstation
Objects of this class will specialize inherited methods.

Figure A-161b. Communication computer workstation methods.

Teletype
Name/Designator

Figure A-162a. Teletype attributes.

Teletype
Ring

Figure A-162b. Teletype methods.

Link
Location Status FIber Optic Multiplex

Figure A-163a. Link attributes.

Link
Objects of this class will specialize inherited methods.

Figure A-163b. Link methods.

Courier
Military Civilian

Figure A-164a. Courier attributes.

Courier
Objects of this class will specialize inherited methods.

Figure A-164b. Courier methods.

Relay
Location: Air Ground Satellite Frequency Receive Frequency Transmit Equipment Type Type of Relay: Automatic Manual

Figure A-165a. Relay attributes.

Relay
Objects of this class will specialize inherited methods.

Figure A-165b. Relay methods.

Communication Line
Connectivity Mode: Fiber Optic Copper Radio Frequency

Figure A-166a. Line attributes.

Communication Line
Objects of this class will specialize inherited methods.

Figure A-166b. Line methods.

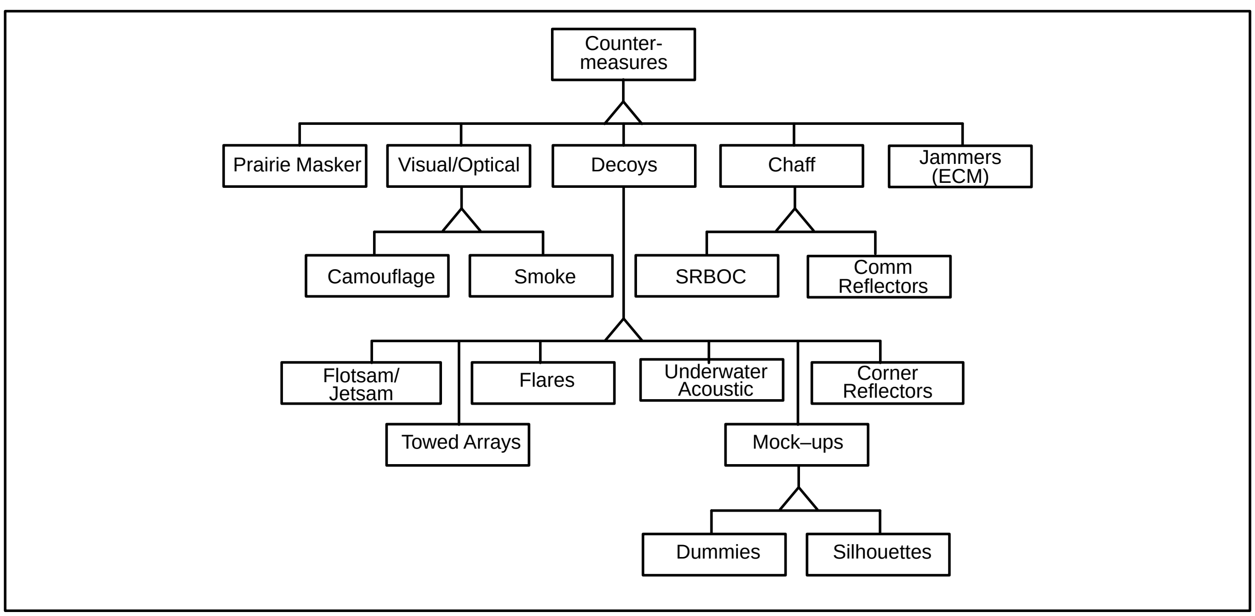


Figure A-167. Countermeasures.

Countermeasures
Type Spectrum Position

Figure A-168a. Countermeasures attributes.

Countermeasures
Deceive Manipulate Confuse

Figure A-168b. Countermeasures methods.

Prairie Air/Masker Belts
Cycle Time Number of Belts

Figure A-169a. Prairie air/masker belts attributes.

Prairie Air/Masker Belts
Dispense Bubbles Masks Sound

Figure A-169b. Prairie air/masker belts methods.

Visual/Optical
Target Size Occlusion Height of Eye

Figure A-170a. Visual/optical attributes.

Visual/Optical
Objects of this class will specialize inherited methods.

Figure A-170a. Visual/optical attributes.

Camouflage
Color Style Size Amount

Figure A-171a. Camouflage attributes.

Camouflage
Blocks

Figure A-171b. Camouflage methods.

Smoke
Generator Amount

Figure A-172a. Smoke attributes.

Smoke
Obscure

Figure A-172b. Smoke methods.

Decoys
Deployment/Launch Mode

Figure A-173a. Decoys attributes.

Decoys
Launch Provides False Information

Figure A-173b. Decoys methods.

Flotsam/Jetsom
Material Content

Figure A-174a. Flotsam/jetsom attributes.

Flotsam/Jetsom
Float Drift

Figure A-174b. Flotsam/jetsom methods.

Towed Array
Length
Frequency
Type
Electrical
Mechanical
Power Output
Noise Output
Effective Range

Figure A-175a. Towed array attributes.

Towed Array
Radiate

Figure A-175b. Towed array methods.

Flares
Source Level
Launch Method
Life

Figure A-176a. Flares attributes.

Flares
Burn

Figure A-176b. Flares methods.

Underwater Acoustic
Source Level
Trailing Length
Modulation
Codes
Depth
Launch Method

Figure A-177a. Underwater acoustic attributes.

Underwater Acoustic
Makes Noise

Figure A-177b. Underwater acoustic methods.

Mock-Ups
Size_Unassembled
Size_Assembled
Weight
Type
TimeToAssemble
Materials

Figure A-178a. Mock-ups attributes.

Mock-Ups
Objects of this class will specialize inherited methods.

Figure A-178b. Mock-ups methods.

Corner Reflectors
Size
Location

Figure A-179a. Corner reflectors attributes.

Corner Reflectors
Reflect

Figure A-179b. Corner reflectors methods.

Chaff
Spectrum
Burst Size (radar cross section)
Amount/Number of Bursts

Figure A-180a. Chaff attributes.

Chaff
Dispenses
Reflects

Figure A-180b. Chaff attributes.

Jammers
Power
Azimuth Resolution
Pulse Analysis Parameters
Sensitivity
Antenna Type/Parameters
Effective Range
Effective Bandwidth
Library
Memory
Receiver Type

Figure A-181a. Jammers attributes.

Jammers
Detect
Locate
Match Frequency
Transmit

Figure A-181b. Jammers methods.

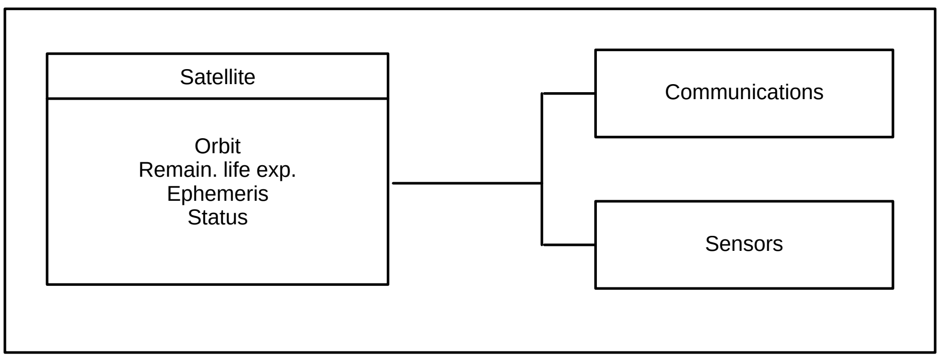


Figure A-182. Satellite class.

Satellite
Status
Location
Synchronous Orbit
Near Polar Orbit
Polar Orbit
Controllable Orbit
Aircraft Boost Launch
Heavy Vehicle Boost Launch
Recoverable Vehicle Launch
Time Limited
Power Limited
Sensor Resources Limited
Solar
Battery
Nuclear
Lifespan
Remaining Life Expectancy
Weight
Launch Date
Ephemeris

Figure A-183a. Satellite attributes.

Satellite
Moves
Rotate
Revolve
Generate Power
Rendezvous
Transmit
Receive
Collect
Deploys On-board Equipment

Figure A-183b. Satellite methods.

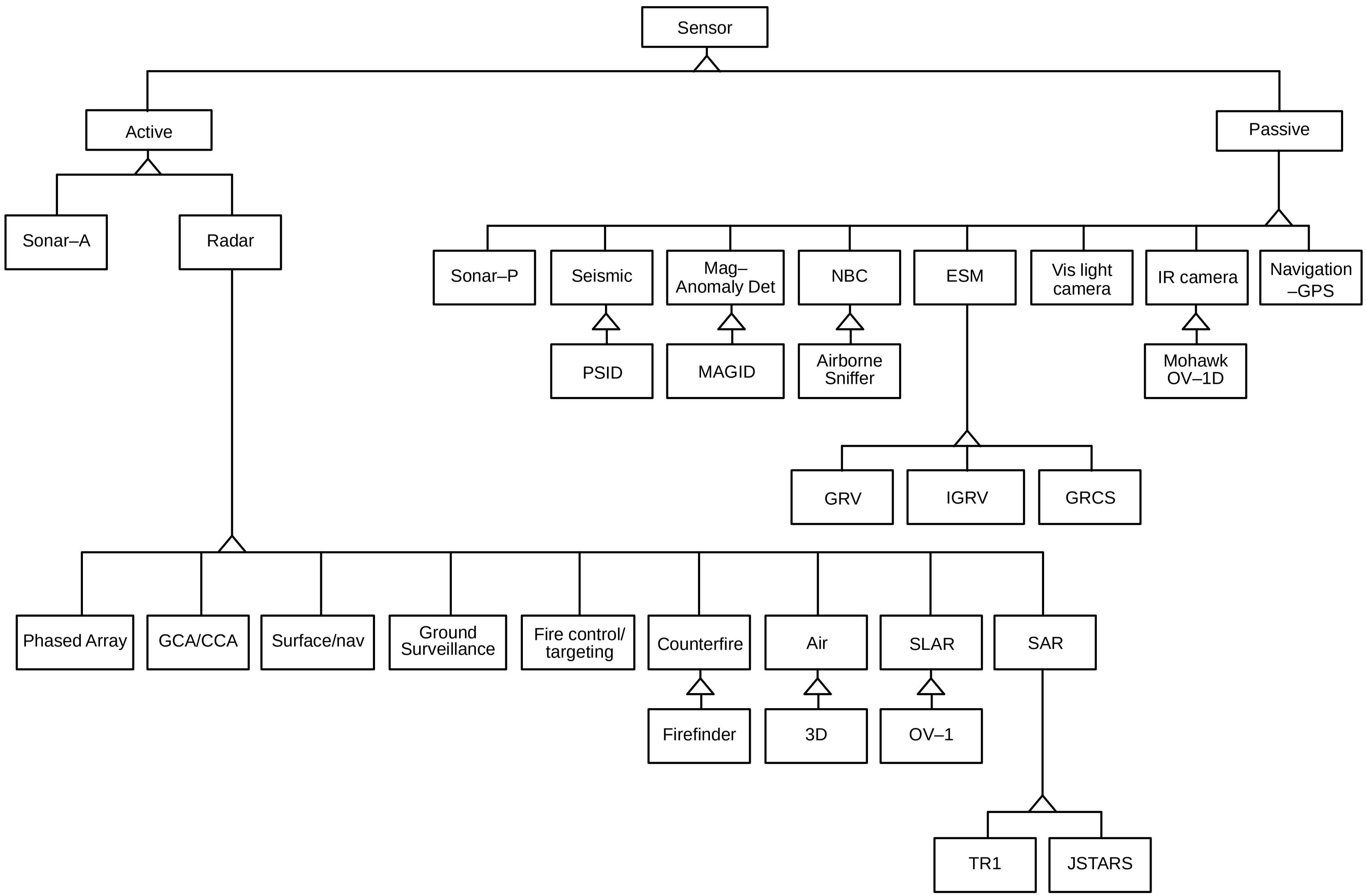


Figure A-184. Sensor subtree.

Sensor Class
Function Size (dimensions) Weight Power Operating Spectrum (band) Operating Ranges (environmental parameters) Update Rates Arcs of Primary and Secondary Operation Blind Areas Wave Propagation ECCM Status Frequency Location

Figure A-185a. Sensor class attributes.

Sensor Class
Detect Locate Identify Track Report Analyze Exchange Data

Figure A-185b. Sensor class methods.

Active Class
Counter-Detection Range ECCM Target Range Target Bearing Target Aspect Power/Source Level

Figure A-186a. Active class attributes.

Active Class
Emit

Figure A-186b. Active class methods.

Active Sonar and Underwater Sound
Type Distortion Load Duty Cycle Linearity Gain Sensitivity Range Range Accuracy Bearing Accuracy Bearing Resolution Auto Tracking Channels Tracking Parameters Doppler Resolution Beams Pulse Length Staves Directivity Index Transducer Type/Number Hydrophone Type/Number Depth

Figure A-187a. Active sonar and underwater sound attributes.

Active Sonar and Underwater Sound
Determine Sound Velocity Profile

Figure A-187b. Active sonar and underwater sound methods.

Radar
Beam Characteristics PRF Pulse Width Antenna Characteristics (size, weight, wind loading) Gain Modulation Processing Methods Polarization

Figure A-188a. Radar attributes.

Radar
Objects of this class will specialize inherited methods.

Figure A-188b. Radar methods.

Passive Class
Type

Figure A-189a. Passive class attributes.

Passive Class
Objects of this class will specialize inherited methods.

Figure A-189b. Passive class methods.

Passive Sonar and Underwater Sound
Linearity Gain Sensitivity Bearing Accuracy Bearing Resolution Auto Tracking Channels Doppler Resolution Beams Staves Directivity Index Hydrophone Type/Number Depth

Figure A-190a. Passive sonar and underwater sound attributes.

Passive Sonar and Underwater Sound
Objects of this class will specialize inherited methods.

Figure A-190b. Passive sonar and underwater sound methods.

Seismic
Source Level Duration Sensitivity Parameter Measurement

Figure A-191a. Seismic attributes.

Seismic
Objects of this class will specialize inherited methods.

Figure A-191b. Seismic methods.

Magnetic
Sensitivity Background Noise Measurement Range Slant Range

Figure A-192a. Magnetic attributes.

Magnetic
Objects of this class will specialize inherited methods.

Figure A-192b. Magnetic methods.

NBC
Parameter Measurement Sensitivity

Figure A-193a. NBC attributes.

NBC
Objects of this class will specialize inherited methods.

Figure A-193b. NBC methods.

ESM
Type Azimuth Resolution Pulse Analysis Parameters Sensitivity Antenna Type/Parameters Effective Range Effective Bandwidth Antenna

Figure A-194a. ESM attributes.

ESM
Objects of this class will specialize inherited methods.

Figure A-194b. ESM methods.

Visual (optronics)
Type Frequency Range Field of View Resolution Sensitivity Image Output Format Interfaces Aspect Ratio Stabilization Magnification Elevation Scanning Photoelectric Photoconductive Photoelectromagnetic

Figure A-195a. Visual (optronics) attributes.

Visual (optronics)
Objects of this class will specialize inherited methods.

Figure A-195b. Visual (optronics) methods.

IR Camera
Micron Type Frequency Range Field of View Resolution Sensitivity Image Output Format Interfaces Aspect Ratio Stabilization Magnification Elevation Scanning

Figure A-196a. IR camera attributes.

IR Camera
Produce Physical Product

Figure A-196b. IR camera methods.

Navigation/GPS
Type (GPS/LORAN/OMEGA/TERCON, etc.) Orbit Type Clock Life Field Position Altitude Coordinate System Accuracy Magnetic Variation Map Datum Regional Identifiers Data Interface Port Configuration

Figure A-197a. Navigation/GPS attributes.

Navigation/GPS
Objects of this class will specialize inherited methods.

Figure A-197b. Navigation/GPS methods.

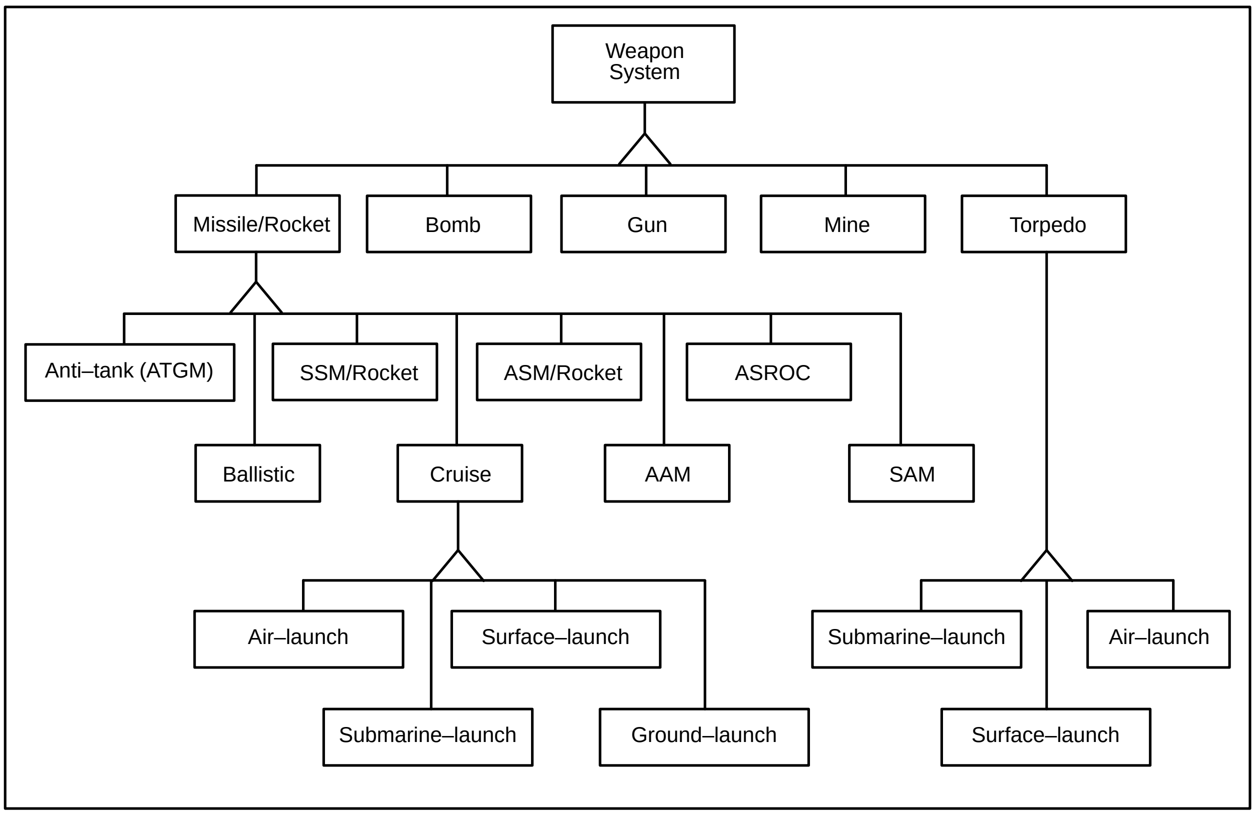


Figure A-198. Weapon system.

Weapon
Location Status

Figure A-199a. Weapon attributes.

Weapon
Locate Track Shoot

Figure A-199b. Weapon methods.

Missile/Rocket
Warhead Type Warhead Dimensions Weight Mobility Range Max Speed Guidance System Weapon Platform CEP

Figure A-200a. Missile/rocket attributes.

Missile/Rocket
Guide Self Launch Fly Arrive Destruct Arm Self

Figure A-200b. Missile/rocket methods.

Bomb
Type Dimensions Weight Guidance

Figure A-201a. Bomb attributes.

Bomb
Fall Arrive Destruct Arm Self Detect

Figure A-201b. Bomb methods.

Mine

Size
Type
  Acoustic
  Contact
  Time Fuse
  Electronic
Placement Method
Placement Depth
Moored
Lifetime
Target Selectivity

Figure A-202a. Mine attributes.

Mine
Move Detect Destruct Arm Self

Figure A-202b. Mine methods.

Torpedo
Speed Range Warhead Size Guidance Launch Platform Power Plant Weight

Figure A-203a. Torpedo attributes.

Torpedo
Destruct Arm Self

Figure A-203b. Torpedo methods.

Gun
Size Weight Range

Figure A-204a. Gun attributes.

Gun
Reload

Figure A-204b. Gun methods.

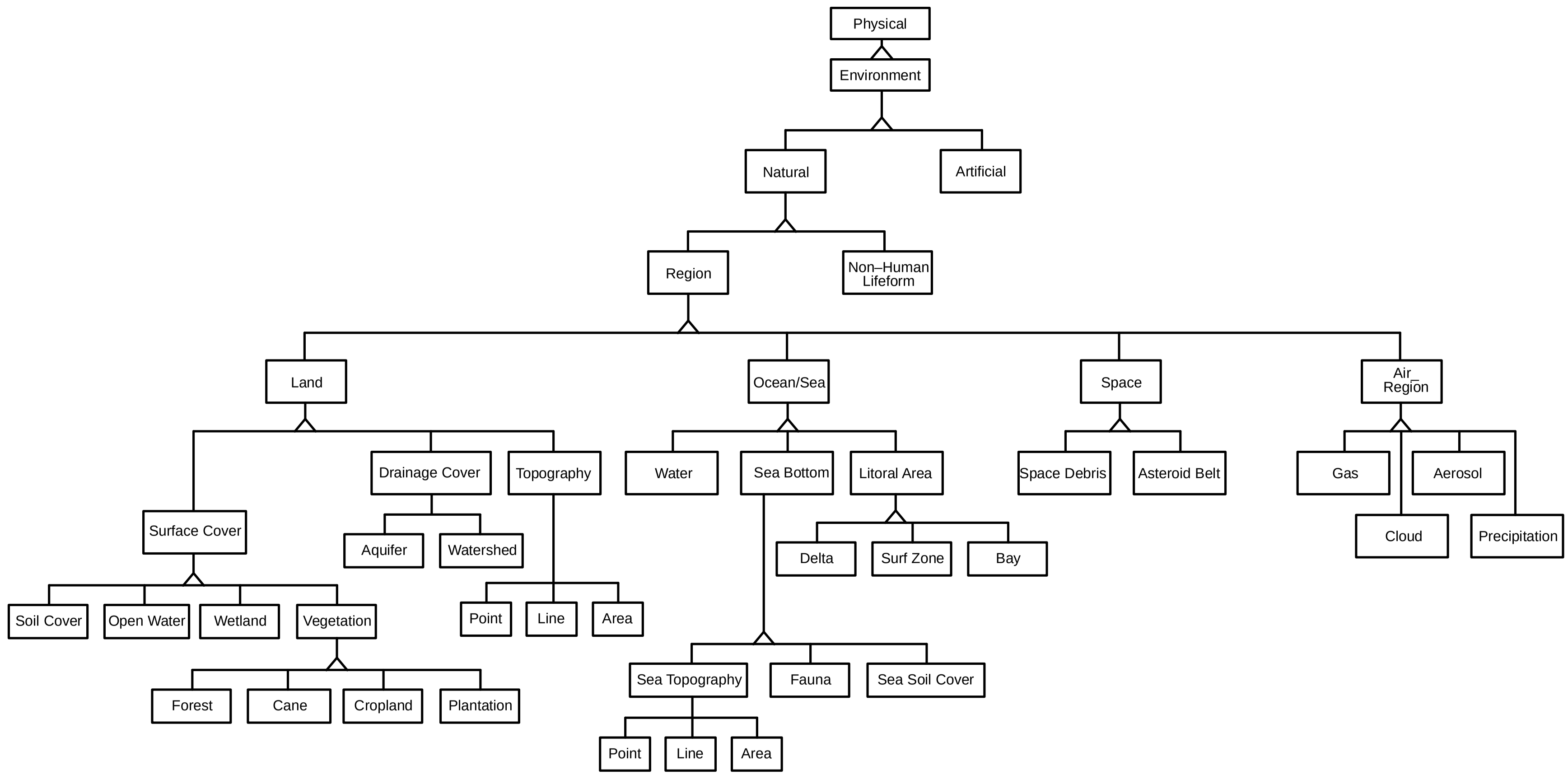


Figure A-205. Natural environment

Region
Location Area Boundaries

Figure A-206a. Region attributes.

Region
Get/Set Location Get/Set Area Get/Set Boundaries

Figure A-206b. Region methods.

Soil Cover
Type: (one or some of) Sand Gravel Dirt Clay Rock Ice Snow Permafrost Friability Water Absorption Rate

Figure A-207a. Soil cover attributes.

Soil Cover
Get/Set Type Get/Set Friability Get/Set Water Absorption Rate

Figure A-207b. Soil cover methods.

Open Water
Depth Potability Navigability Flow Direction Flow Rate Islands

Figure A-208a. Open water attributes.

Open Water
Get/Set Depth Get/Set Potability Get/Set Navigability Get/Set Flow Direction Get/Set Flow Rate Get/Set Islands

Figure A-208b. Open water methods.

Wetland
Trafficability Channels

Figure A-209a. Wetland attributes.

Wetland
Get/Set Trafficability Get/Set Channels

Figure A-209b. Wetland methods.

Forest
Type Density Trafficability Shelter Cover Flammability Deciduous

Figure A-210a. Forest attributes.

Forest
Get/Set Type Get/Set Density Get/Set Trafficability Get/Set Shelter Get/Set Cover Get/Set Flammability Get/Set Deciduous

Figure A-210b. Forest methods.

Cane
Density
Trafficability
Shelter
Cover

Figure A-211a. Cane attributes.

Cane
Get/Set Density
Get/Set Trafficability
Get/Set Shelter
Get/Set Cover

Figure A-211b. Cane methods.

Cropland
Type
Harvestable Food Value
Harvestable Food Cost
Passage Constraints

Figure A-212a. Cropland attributes.

Cropland
Get/Set Type
Get/Set Harvestable Food Value
Get/Set Harvestable Food Cost
Get/Set Passage Constraints

Figure A-212b. Cropland methods.

Plantation
Crop
Setting

Figure A-213a. Plantation attributes.

Plantation
Get/Set Crop
Get/Set Setting

Figure A-213b. Plantation methods.

Aquifer
Depth
Salinity
Estimated Volume

Figure A-214a. Aquifer attributes.

Aquifer
Get/Set Depth
Get/Set Salinity
Get/Set Estimated Volume

Figure A-214b. Aquifer methods.

Watershed
Average Annual Rainfall
Average Annual Runoff
Flood Zone
Exit

Figure A-215a. Watershed attributes.

Watershed
Get/Set Average Annual Rainfall
Get/Set Average Annual Runoff
Get/Set Flood Zone
Get/Set Exit

Figure A-215b. Watershed methods.

Topography
Plain
Hill
Mountain
Desert
Savannah
Valley
Basin and Range
Mesa
Subterranean

Figure A-216a. Topography attributes.

Topography
Get/Set Plain
Get/Set Hill
Get/Set Mountain
Get/Set Desert
Get/Set Savannah
Get/Set Valley
Get/Set Basin and Range
Get/Set Mesa
Get/Set Subterranean

Figure A-216b. Topography methods.

Ocean/Sea Water
Depth Salinity Turbidity Visibility Swell Wave Height Temperature Flow Direction Flow Rate Surface Vegetation

Figure A-217a. Ocean/sea water attributes.

Ocean/Sea Water
Get/Set Depth Get/Set Salinity Get/Set Turbidity Get/Set Visibility Get/Set Swell Get/Set Wave Height Get/Set Temperature Get/Set Flow Direction Get/Set Flow Rate Get/Set Surface Vegetation

Figure A-217b. Ocean/sea water methods.

Sea Bottom Topography
Seamounts Rolling Abyssal Plain Trench

Figure A-218a. Sea bottom topography attributes.

Sea Bottom Topography
Get/Set Seamounts Get/Set Rolling Get/Set Abyssal Plain Get/Set Trench

Figure A-218b. Sea bottom topography methods.

Sea Bottom Fauna
Density Distribution Location Sound Absoprtion

Figure A-219a. Sea bottom fauna attributes.

Sea Bottom Fauna
Get/Set Density Get/Set Distribution Get/Set Location Get/Set Sound Absoprtion

Figure A-219b. Sea bottom fauna methods.

Sea Bottom Soil Cover
Type: (one or some of) Sand Gravel Rock Silt Coral Sound Absorption

Figure A-20a. Sea bottom soil cover attributes.

Sea Bottom Soil Cover
Get/Set Type Get/Set Sound Absorption

Figure A-220b. Sea bottom soil cover methods.

Littoral Area
Area

Figure A-221a. Littoral area attributes.

Littoral Area
GetSet Area

Figure A-221b. Littoral area methods.

Delta
Length Breadth Habitation

Figure A-222a. Delta attributes.

Delta
Get/Set Length Get/Set Breadth Get/Set Habitation

Figure A-222b. Delta methods.

Surf Zone

Bottom Type
  Sand
  Coral
  Rock
  Gravel
Gradient
Wave Speed
Wave Break
Riptides

Figure A-223a. Surf zone attributes.

Surf Zone
Get/Set Bottom Type Get/Set Gradient Get/Set Wave Speed Get/Set Wave Break Get/Set Riptides

Figure A-223a. Surf zone attributes.

Bay
Depth Trafficability Shelter

Figure A-224a. Bay attributes.

Bay
Get/Set Depth Get/Set Trafficability Get/Set Shelter

Figure A-224b. Bay methods.

Space
Orbit Location Orbit Type

Figure A-224c. Space attributes.

Space
Get/Set Orbit Location Get/Set Orbit Type

Figure A-224d. Space methods.

Space Debris
Volume Density

Figure A-225a. Space debris attributes.

Space Debris
Get/Set Volume Get/Set Density

Figure A-225b. Space debris methods.

Asteroid Belt
Volume Density

Figure A-226a. Asteroid attributes.

Asteroid Belt
Get/Set Volume Get/Set Density

Figure A-226b. Asteroid methods.

Air

- Temperature
- Flow Direction
- Flow Rate
- Level
  - Strato
  - Tropo
  - Iono
- Visibility

Figure A-227a. Air attributes.

Air

- Get/Set Temperature
- Get/Set Flow Direction
- Get/Set Flow Rate
- Get/Set Level
- Get/Set Visibility

Figure A-227b. Air methods.

Gas

- Oxygen Content
- Human-Adverse Content

Figure A-228a. Gas attributes.

Gas

- Get/Set Oxygen Content
- Get/Set Human-Adverse Content

Figure A-228b. Gas methods.

Cloud

- Type
- Lower Ceiling
- Upper Ceiling
- Make Up
  - Smoke
  - Dust
  - Steam
  - Precipitation

Figure A-229a. Cloud attributes.

Cloud

- Get/Set Type
- Get/Set Lower Ceiling
- Get/Set Upper Ceiling
- Get/Set Make Up

Figure A-229b. Cloud methods.

Aerosol

- Composition
- Density

Figure A-230a. Aerosol attributes.

Aerosol

- Get/Set Composition
- Get/Set Density

Figure A-230b. Aerosol methods.

Precipitation

- 24-Hour Rate
- Short-Term Rate
- Form
  - water/ice/hail/snow

Figure A-231a. Precipitation attributes.

Precipitation

- Get/Set 24-Hour Rate
- Get/Set Short-Term Rate
- Get/Set Form

Figure A-231b. Precipitation methods.

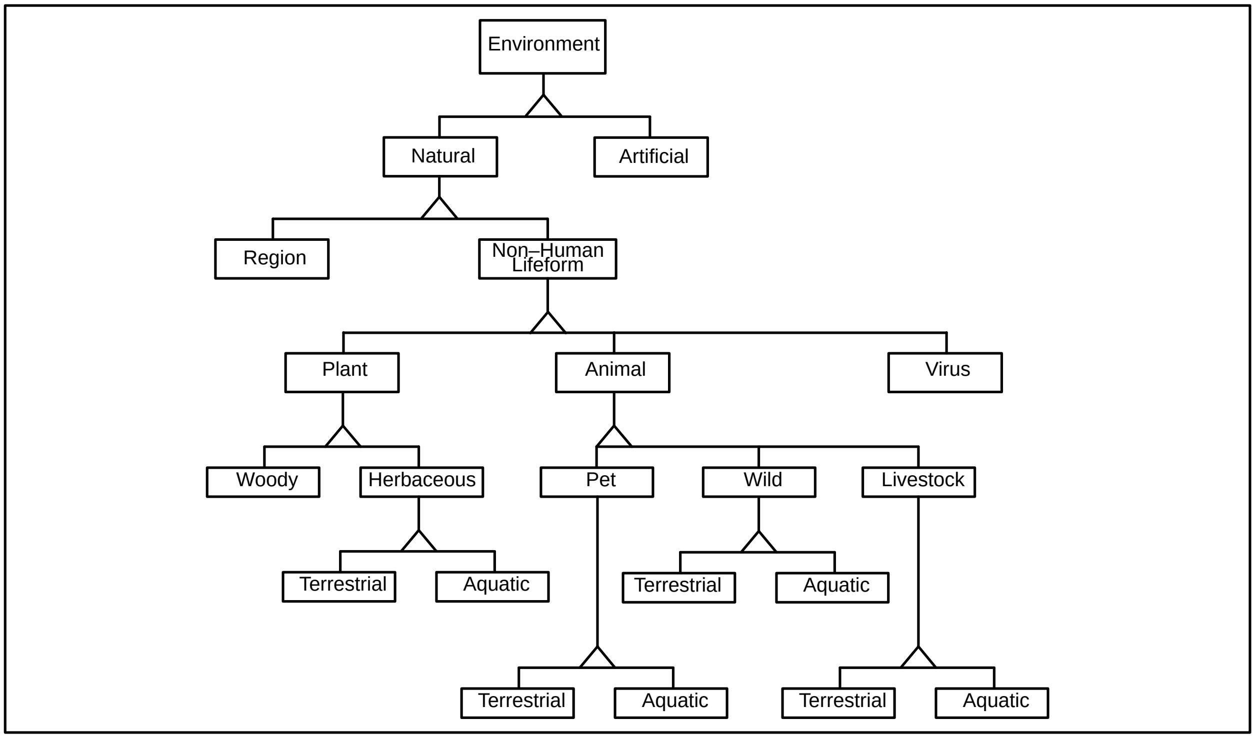


Figure A-232. Non-human.

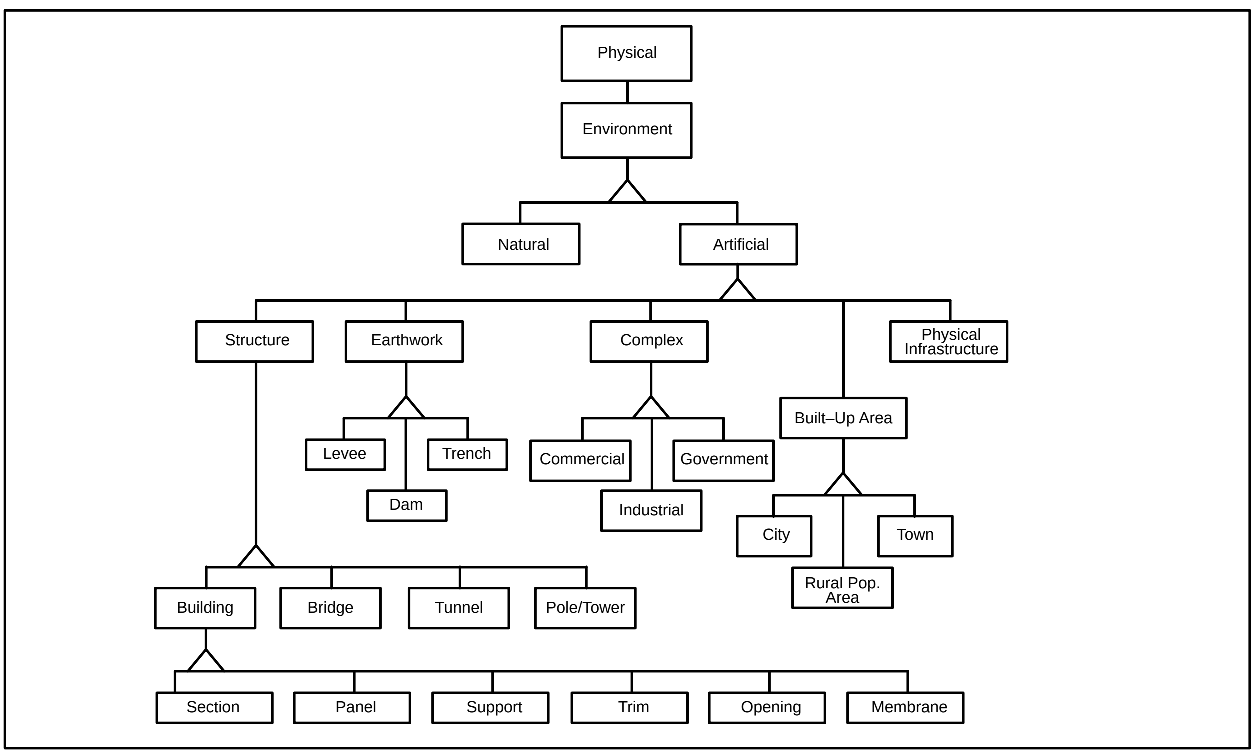


Figure A-233. Artificial.

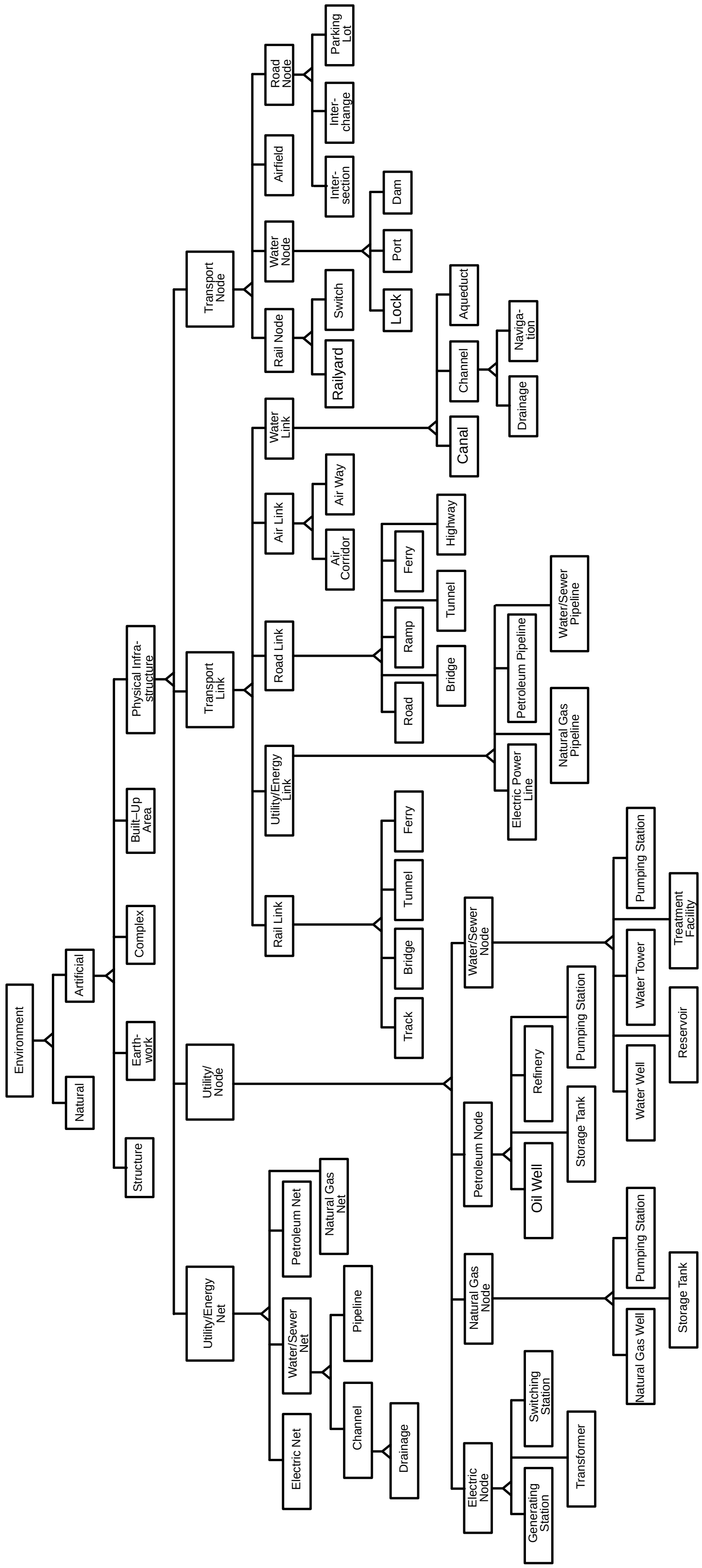


Figure A-234. Physical infrastructure subtree.

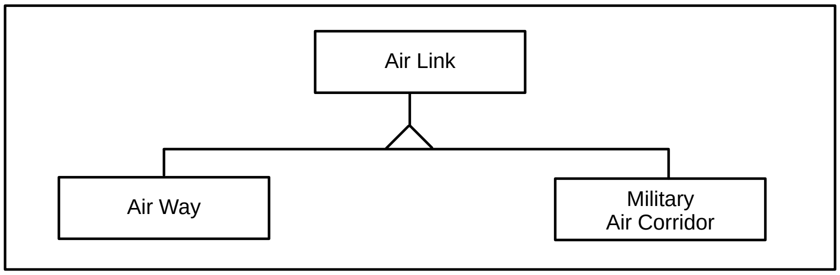


Figure A-235. Air link subclass.

Air Way
Air Way Name Super High Alt Upper Super High Alt Lower High Alt Upper High Alt Lower Low Alt Upper Low Alt Lower

Figure A-236a. Air way attributes.

Air Way
Get/Set Air Way Name Get/Set Super High Alt Upper Get/Set Super High Alt Lower Get/Set High Alt Upper Get/Set High Alt Lower Get/Set Low Alt Upper Get/Set Low Alt Lower

Figure A-236b. Air way methods.

Military Air Corridor
Rtn to Force Altitude Rtn to Force Heading Rtn to Force IFF Rtn to Force Air Speed Departure Altitude Departure Heading Departure IFF Departure Air Speed IFF Code on Rtn to Force Acft iFF Code on Departure Acft

Figure A-236c. Air corridor attributes.

Military Air Corridor
Get/Set Rtn to Force Altitude Get/Set Rtn to Force Heading Get/Set Rtn to Force IFF Get/Set Rtn to Force Air Speed Get/Set Departure Altitude Get/Set Departure Heading Get/Set Departure IFF Get/Set Departure Air Speed Get/Set IFF Code on Rtn to Force Acft Get/Set iFF Code on Departure Acft

Figure A-236d. Air corridor methods.

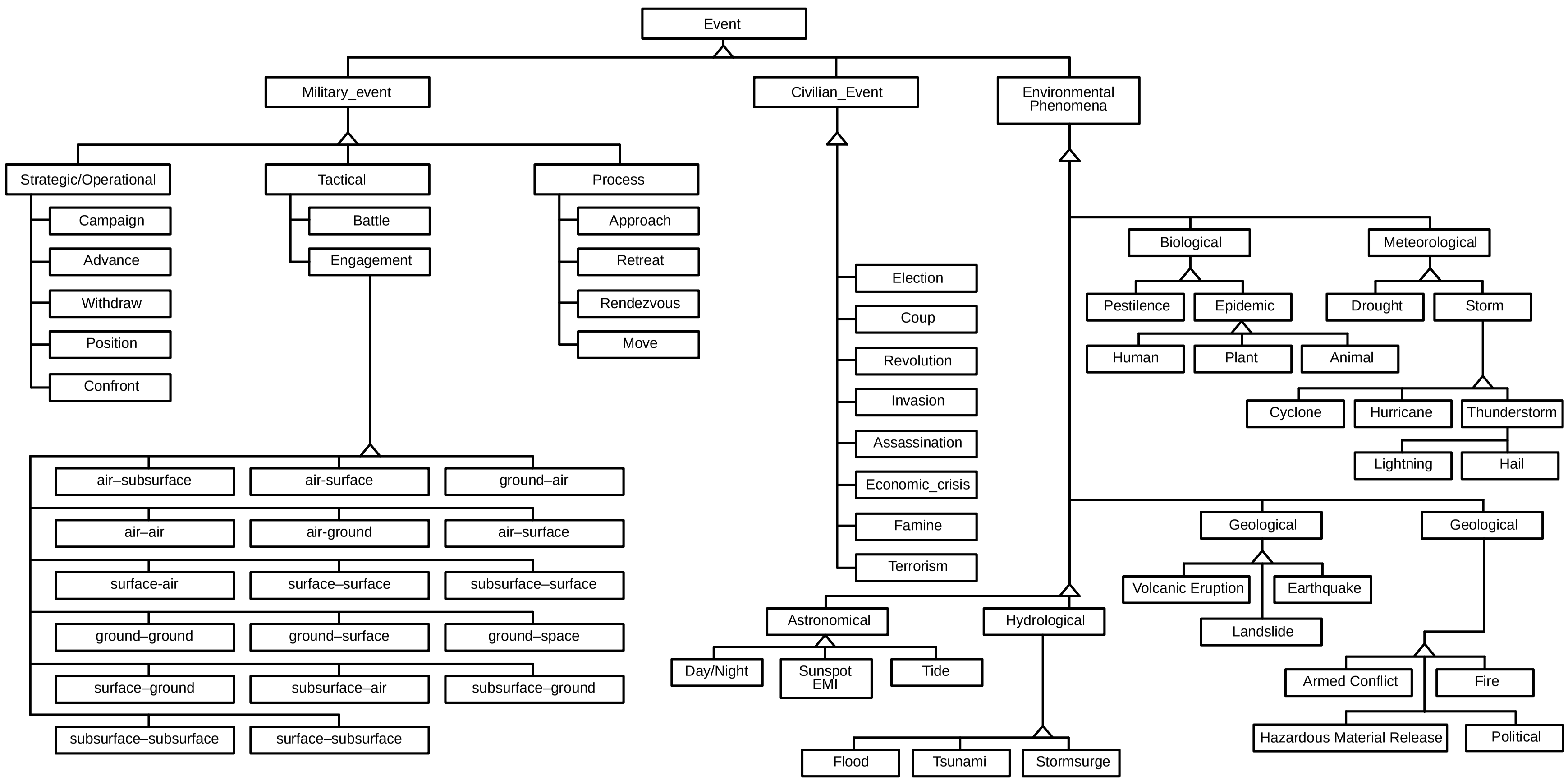


Figure A-237. Event class.

Engagement
Target(s)
Conventional/NBC
Start Condition(s)
Planned Duration
Termination Condition(s)
Regional Location
OPFOR Name
OPFOR Sensing
OPFOR Firepower
OPFOR Mobility

Figure A-238a. Engagement attributes.

Engagement
Get/Set Target(s)
Get/Set Conventional/NBC
Get/Set Start Condition(s)
Get/Set Planned Duration
Get/Set Termination Condition(s)
Get/Set Regional Location
Get/Set OPFOR Name
Get/Set OPFOR Sensing
Get/Set OPFOR Firepower
Get/Set OPFOR Mobility

Figure A-238b. Engagement methods.

Air-Air
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-239a. Air-air attributes.

Air-Air
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-239a. Air-air methods.

Air-Gnd
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-240a. Air-ground attributes.

Air-Gnd
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-240b. Air-ground methods.

Air-Space
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-241a. Air-space attributes.

Air-Space
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-241b. Air-space methods.

Air-Subsurface
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-242a. Air-subsurface attributes.

Air-Subsurface
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-242b. Air-ground methods.

Air-Surface
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-243a. Air-surface attributes.

Air-Surface
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-243b. Air-surface methods.

Gnd-Air
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-244a. Ground-air attributes.

Gnd-Air
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-244b. Ground-air methods.

Gnd-Gnd
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-245a. Ground-ground attributes.

Gnd-Gnd
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-245b. Ground-ground methods.

Gnd-Surface
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-246a. Ground-surface attributes.

Gnd-Surface
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-246b. Ground-surface methods.

Gnd-Space
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-247a. Ground-space attributes.

Gnd-Space
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-247b. Ground-space methods.

Surf-Air
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-248a. Surface-air attributes.

Surf-Air
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-248b. Surface-air methods.

Surf-Surf
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-249a. Surface-surface attributes.

Surf-Surf
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-249b. Surface-surface methods.

Surf-Subsurf
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-250a. Surface-subsurface attributes.

Surf-Subsurf
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-250b. Surface-subsurface methods.

Surf-Gnd
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-251a. Surface-ground attributes.

Surf-Gnd
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-251b. Surface-ground methods.

Subsurf-Air
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-252a. Subsurface-air attributes.

Subsurf-Air
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-252b. Subsurface-air methods.

Subsurf-Gnd
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-253a. Subsurface-ground attributes.

Subsurf-Gnd
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-253b. Subsurface-ground methods.

Subsurf-Surf
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-254a. Subsurface-surface attributes.

Subsurf-Surf
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-254b. Subsurrface-surface methods.

Subsurf-Subsurf
Tactic(s): (default value(s))
Technique(s): (default value(s))
Weapon(s): (default value(s))
Sensor(s): (default value(s))
Communication(s): (default value(s))
Countermeasure(s): (default value(s))

Figure A-255a. Subsurface-subsurface attributes.

Subsurf-Subsurf
Get/Set Tactic(s): (default value(s))
Get/Set Technique(s): (default value(s))
Get/Set Weapon(s): (default value(s))
Get/Set Sensor(s): (default value(s))
Get/Set Communication(s): (default value(s))
Get/Set Countermeasure(s): (default value(s))

Figure A-255b. Subsurface-subsurface methods.

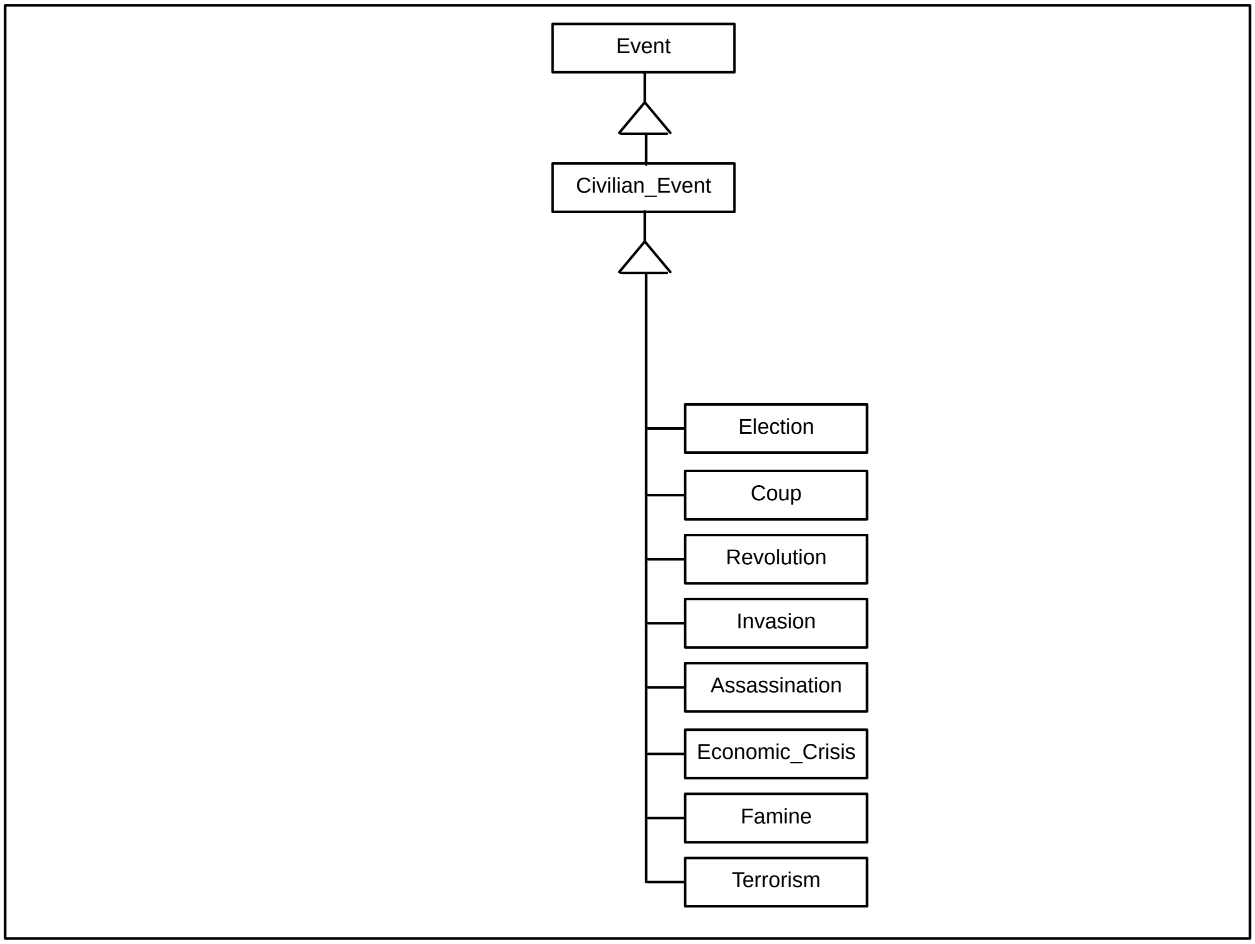


Figure A-256. Non-military event class.

APPENDIX B: SAMPLE THREAD

Appendix B demonstrates how the classes defined in appendix A can be used to model a specific operation. It also shows the use of Event Flows and State Transition Diagrams to model behavior. A description of the thread is provided below.

This operation was chosen for the thread due to its realism and involvement of multiple Services. It is not a highly detailed scenario, but is provided to illustrate the use of the taxonomy.

B.1 THREAD NARRATIVE

An element of the 82nd Division Airborne Infantry Battalion is in contact with an enemy tank platoon (T64s) that poses a threat to Company A on the right flank, and requires immediate Close Air Support (CAS). ("Immediate" in this context has the specific meaning that the CAS is needed now.) Air resources not associated with the Battalion must be redirected.

Present with the Infantry Battalion is an Air Force Forward Air Control (FAC) officer. The Battalion S3 directs the FAC to formulate and issue an immediate air support request. The S3 identifies the unit in contact, its location, and its command frequency, as well as the character of the target. The FAC needs this last to make sure the right kind of ordnance is onboard the aircraft.

The FAC forwards the request to the Tactical Air Control Party (TACP) at the Infantry Brigade level. The TACP determines there is no Brigade-controlled air available in the area. The TACP then contacts the Division TACP. The same process recurs: the Division TACP (lacking available air in this example) contacts the Battlefield Coordination Element (BCE) at the XVIII Corps. (The BCE is an integrated Army/Air Force element at Corps Main HQ.) The BCE determines that a flight of two Marine AV-8Bs have been assigned to him for just such a purpose, i.e., they are uploaded with Rockeye, an anti-tank ordnance.

The BCE contacts the flight leader and informs him of the mission, directs him to the forward air control frequency for mission assignment, provides the call sign, and assigns a Contact Point (CP).

Then the BCE sends back down the communications chain (BCE to Division TACP to Brigade TACP to Battalion FAC) that there are two AV-8Bs with Rockeye inbound, and tells the estimated time of arrival at the CP.

During this time, the FAC relocates as close to the Company Commander as possible, and identifies the appropriate Initial Point (IP) and a Release Point (RP). The pilot checks in with the FAC at the CP, establishing voice communications. The FAC gives the mission briefing, which will update the pilots, provide run-in and release headings, pull-off direction, Time-On-Target (TOT), and the method to be used to mark the target.

The planes then execute the mission and return to base, checking out with everyone with whom they checked in, reporting the FAC's estimate of Bomb Damage Assessment (BDA).

B.2 OT THREAT REPRESENTATION

Figure B-1 shows the flow of events, represented using the Martin/Odell Event Flow notation. Figure B-2 shows the state diagram for the mission of Forward Air Controller. There are four major states: request CAS, prepare to engage, state mission, and estimate BDA. The second of these, prepare to engage, has three substates: relocate to Company Commander; establish mission IP and RP; and await pilot contact.

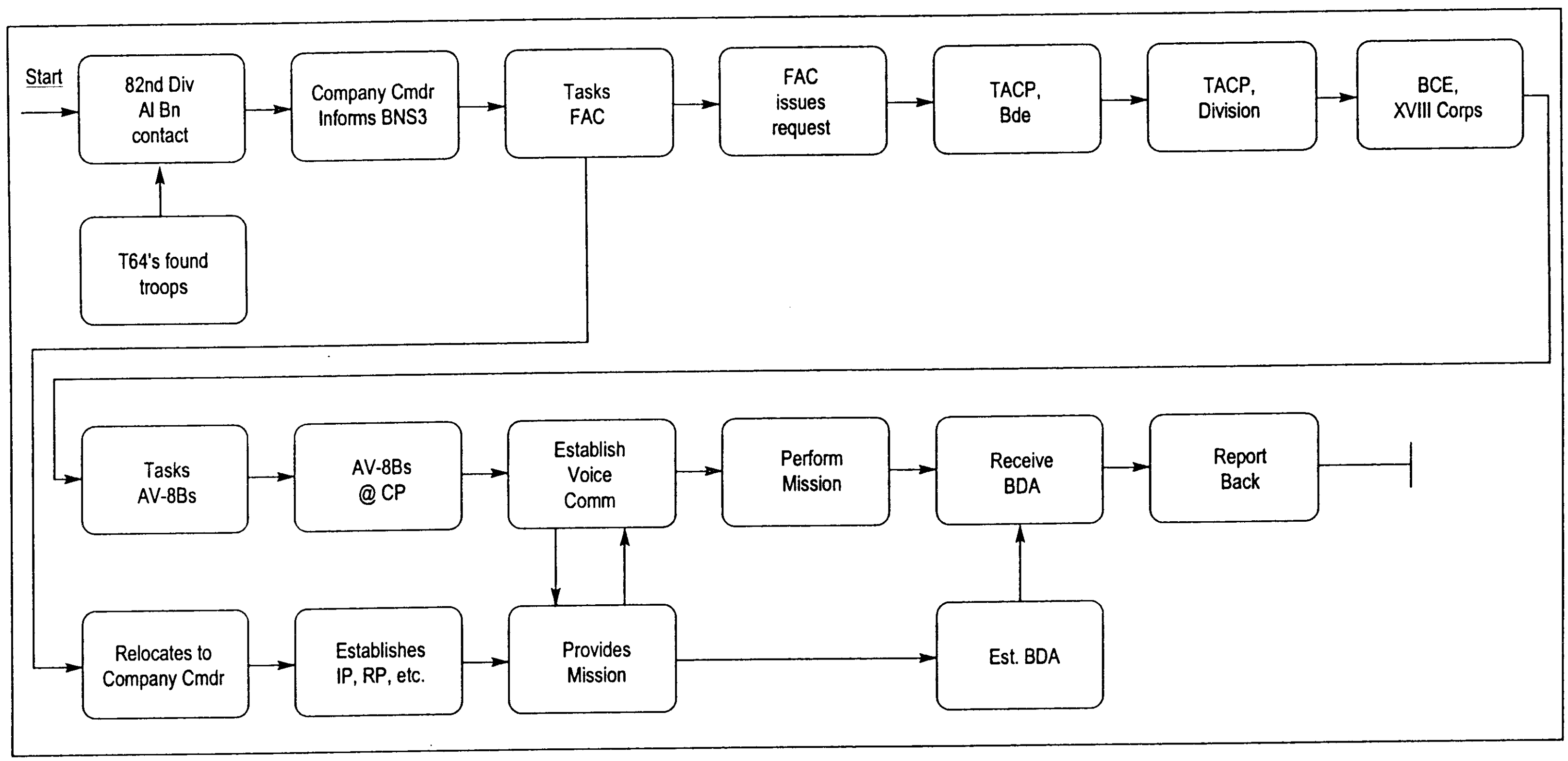


Figure B-1. Martin/Odell event schema.

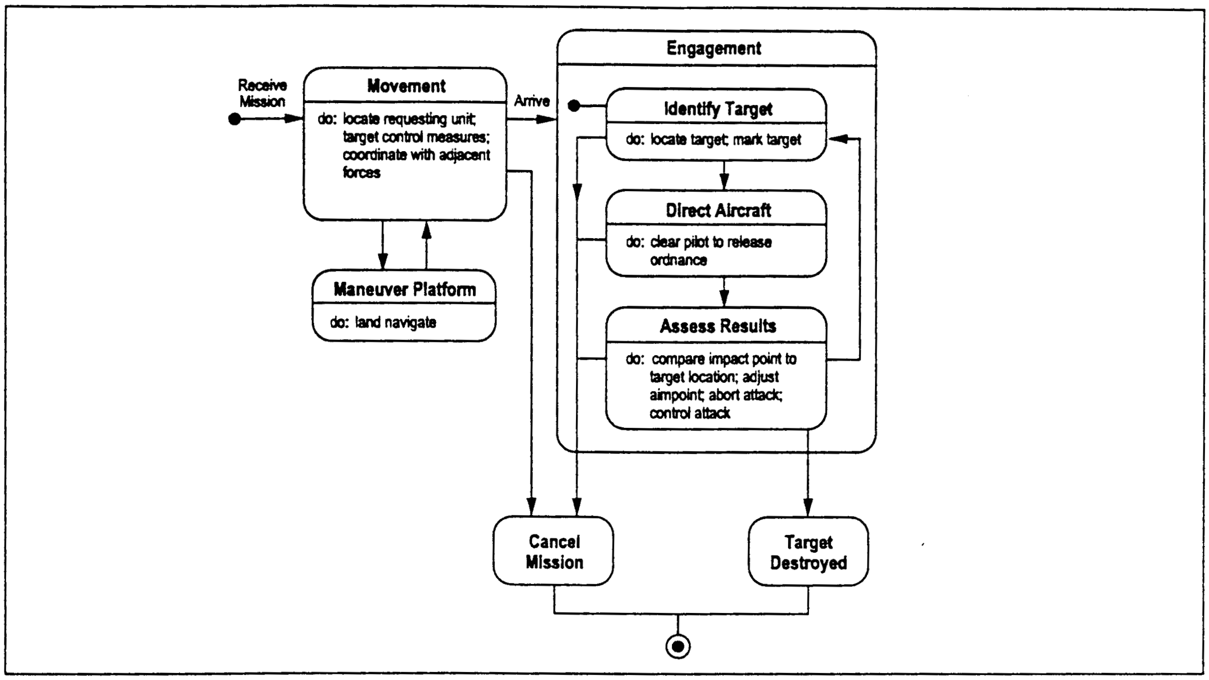


Figure B-2. State diagram for the mission of the Forward Air Controller.

Figures B-3.1 through B-3.11 show the high level classes and objects that implement this scenario and traces the high level Marine Corps thread. Figures B-4a through B-4c show complete definitions for the requisite objects.

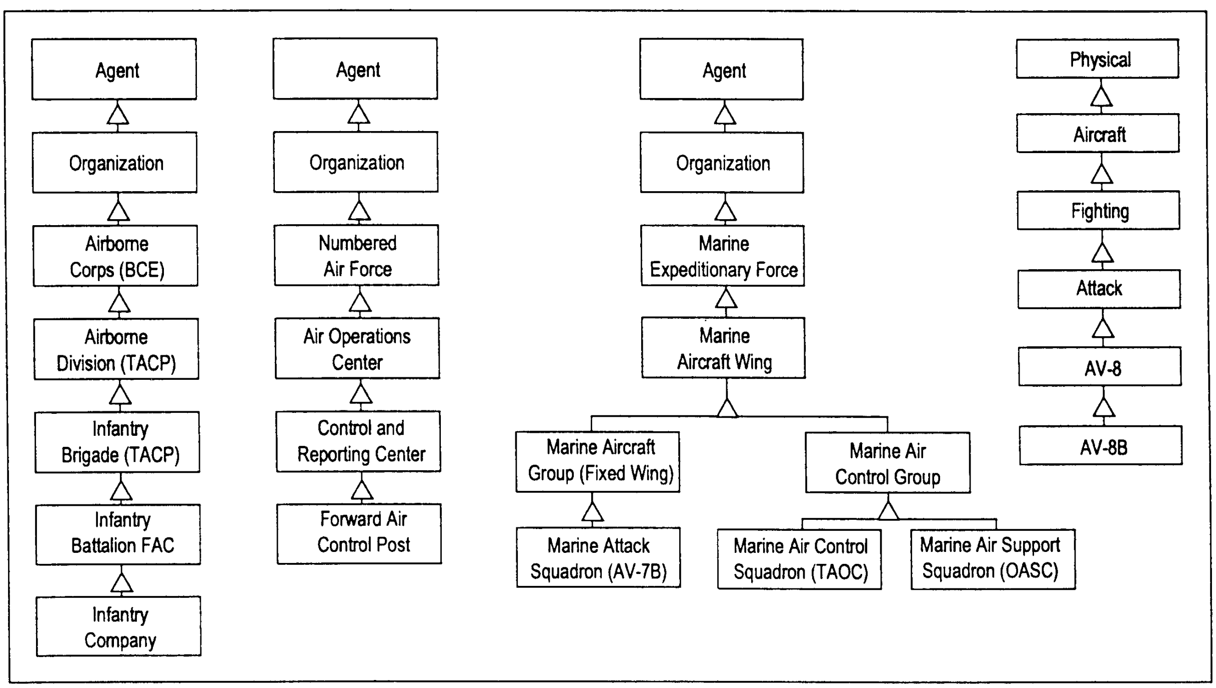


Figure B-3. Scenario implementation high level classes and objects.

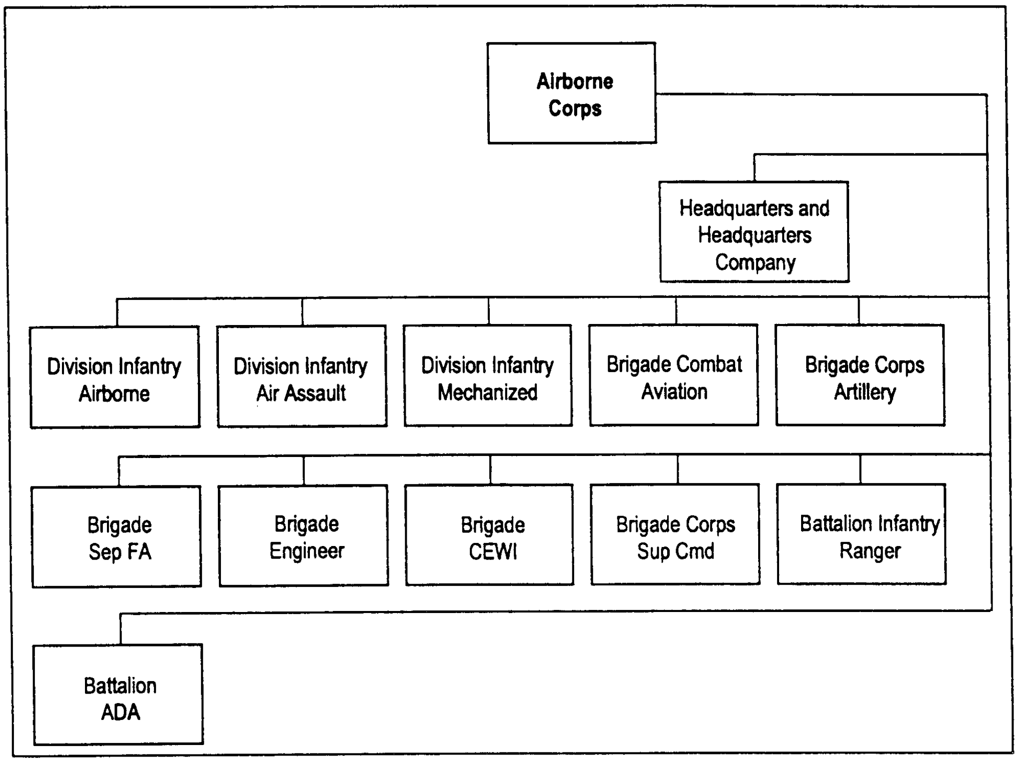


Figure B-3.1. Airborne Corps class.

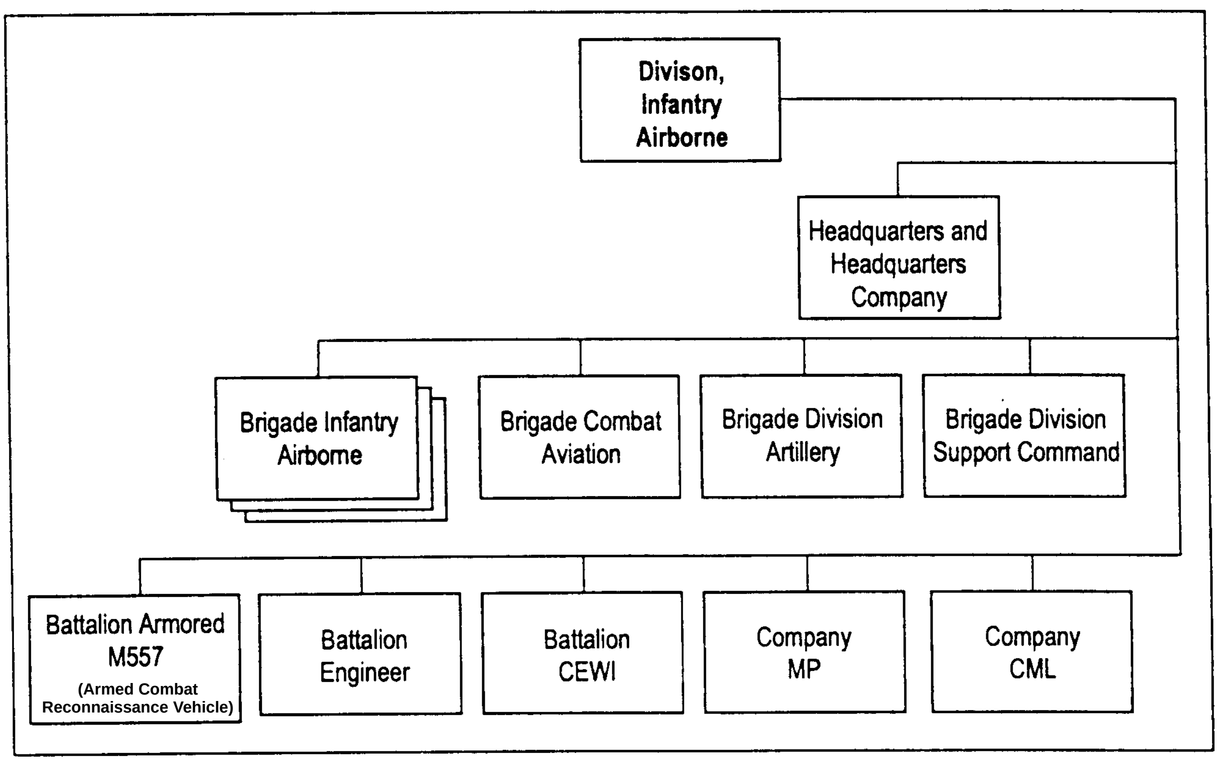


Figure B-3.2. Airborne Division class.

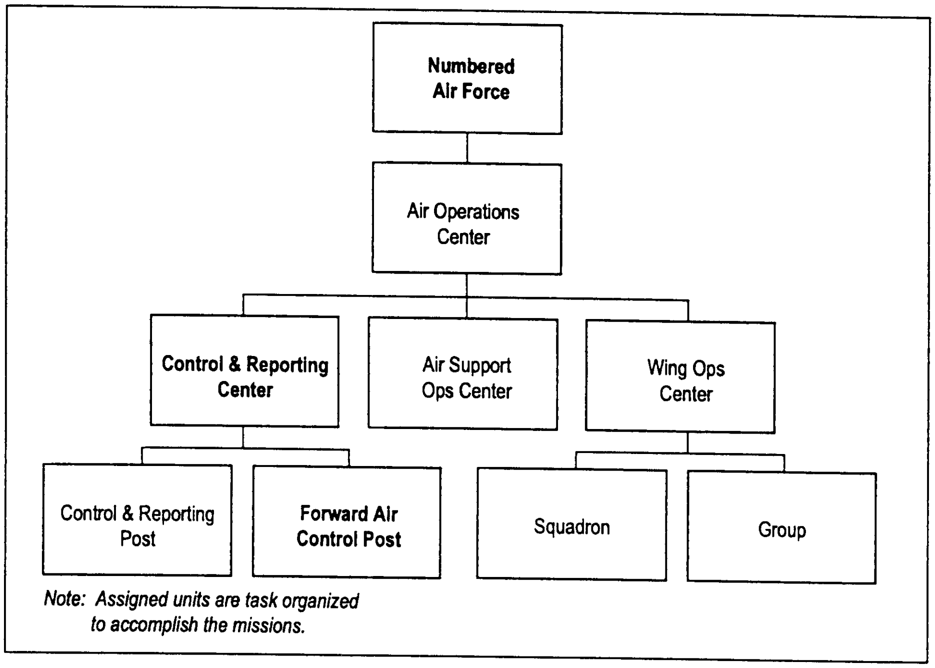


Figure B-3.3. Numbered Air Force, Control and Reporting Center and Forward Air Control Post classes.

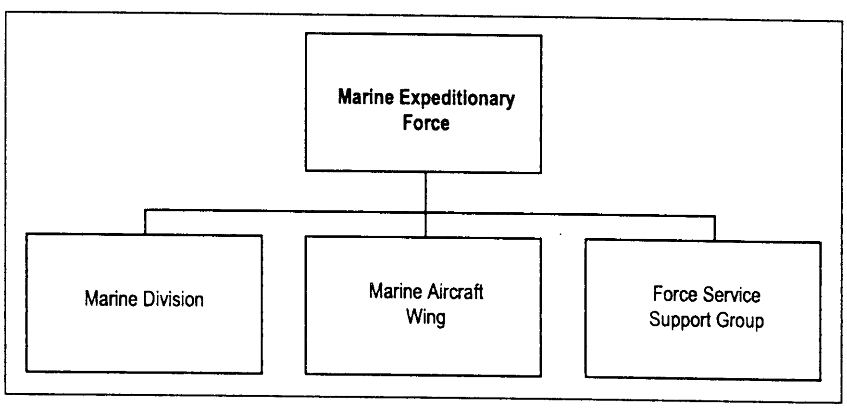


Figure B-3.4. Marine Expeditionary Force class.

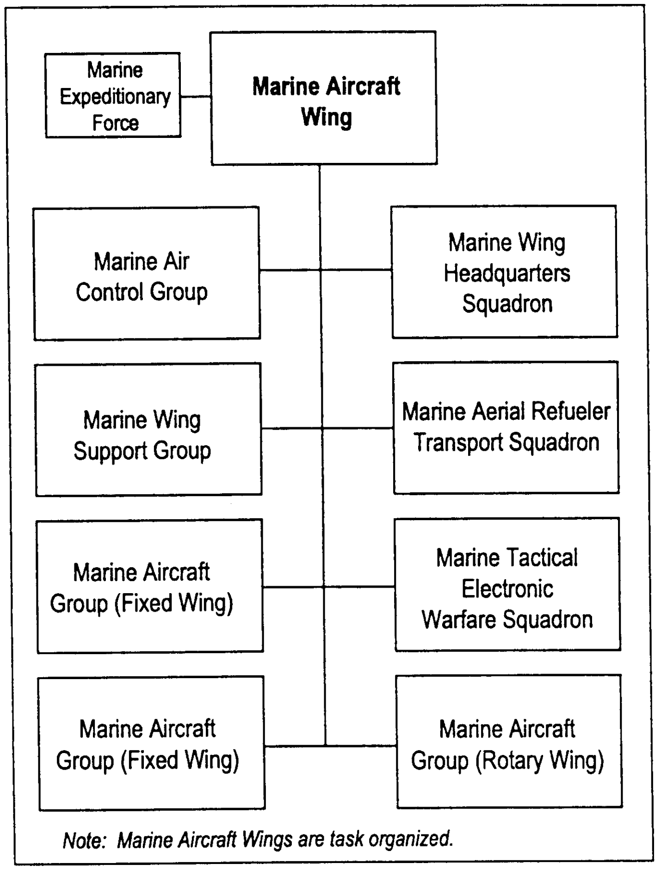


Figure B-3.5. Marine Aircraft Wing class.

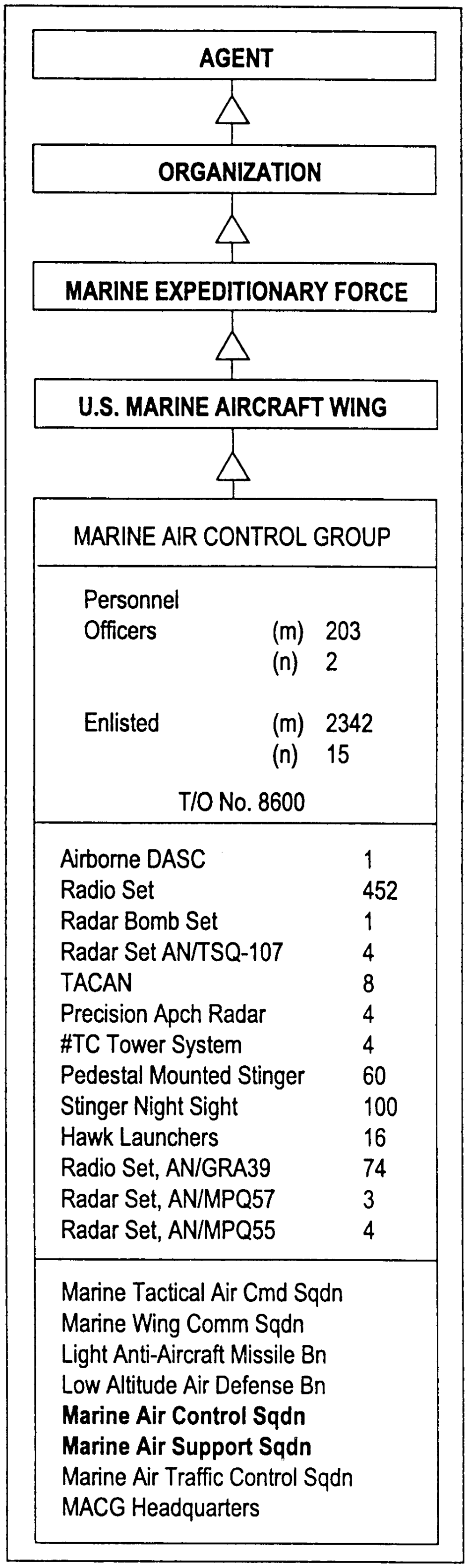


Figure B-3.6. Marine Air Control Group/Squadron and Marine Air Support Squadron classes.

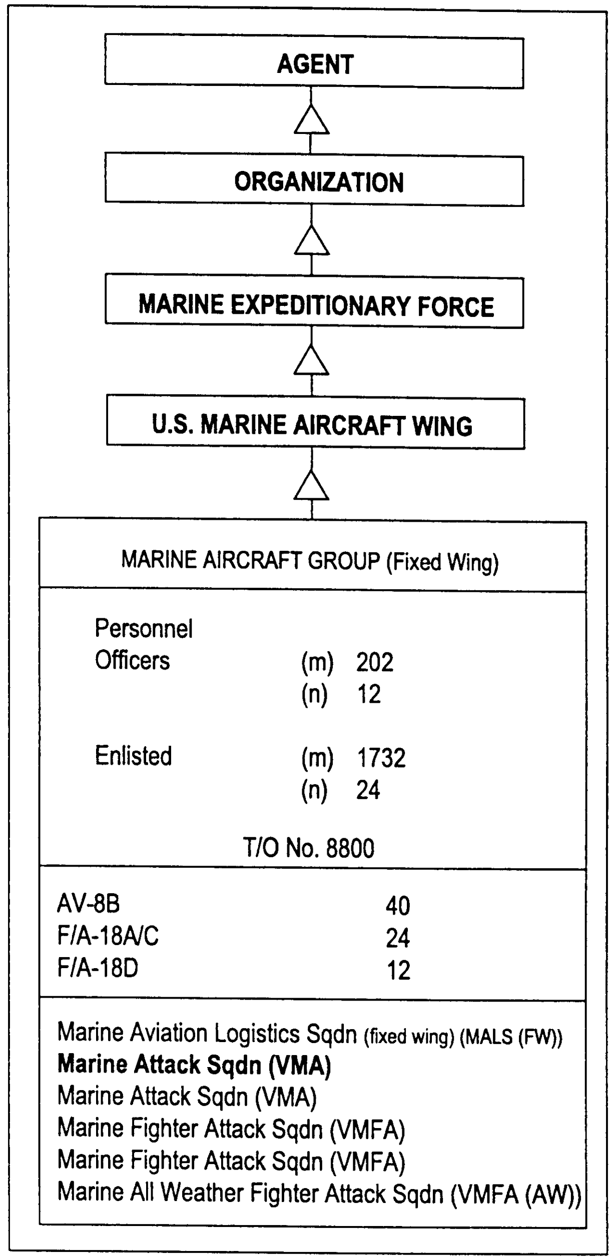


Figure B-3.7. Marine Aircraft Group (Fixed Wing) and Marine Attack Squadron classes.

Aircraft
Type Model Series Crew Location Unrefueled Ferry Range Range with In-Flight Refueling Max Speed - Sea Level Cruise Speed Fuel Capacity Status Threat Signature Min T-O Distance Service Ceiling Min Landing Distance Length Height Wingspan Wheelbase Max Gross T-O Weight Max Climb Rate at Sea Level Number of Engines Identification Country of Origin Country of Operation Max Hover Height Max Hover Weight Empty Weight Scheduled Maintenance Primary Configuration Code IFF Code

Aircraft
Change Status Change Speed Change Course Report Status Take-off Fly Land Refuel Be Maintained Rendezvous Fly in Formation

Figure B-3.8. Aircraft attributes and methods.

Fighting	Fighting
Max Climb Rate "g" Limits +/- Aspect Ratio Max Speed at Altitude Max Range with External Tanks Combat Ceiling External Tank Restrictions Combat Air Patrol Endurance (at distance) Aiming System Electronic Countermeasures Suite Cryptographic Comm Suite Radar Warning Receiver Head Up Display - yes/no	Calculate Max Speed/Altitude Calculate Max Angle of Attack at Speed Evade/Avoid

Figure B-3.9. Fighting attributes and methods.

Attack	Attack
Max External Stores Hi-Lo-Hi Range Bombing System Hellfire, yes/no Maverick, yes/no Sidewinder, yes/no Mk Series Bombs, yes/no Mk Series LGB, yes/no Bullpup, yes/no HARM, yes/no Rockeye, yes/no CBU59, yes/no GATOR Mines, yes/no Laser Spot Tracker, yes/no	Strafe Drop Bomb Launch Rockets

Figure B-3.10. Attack attributes and methods.

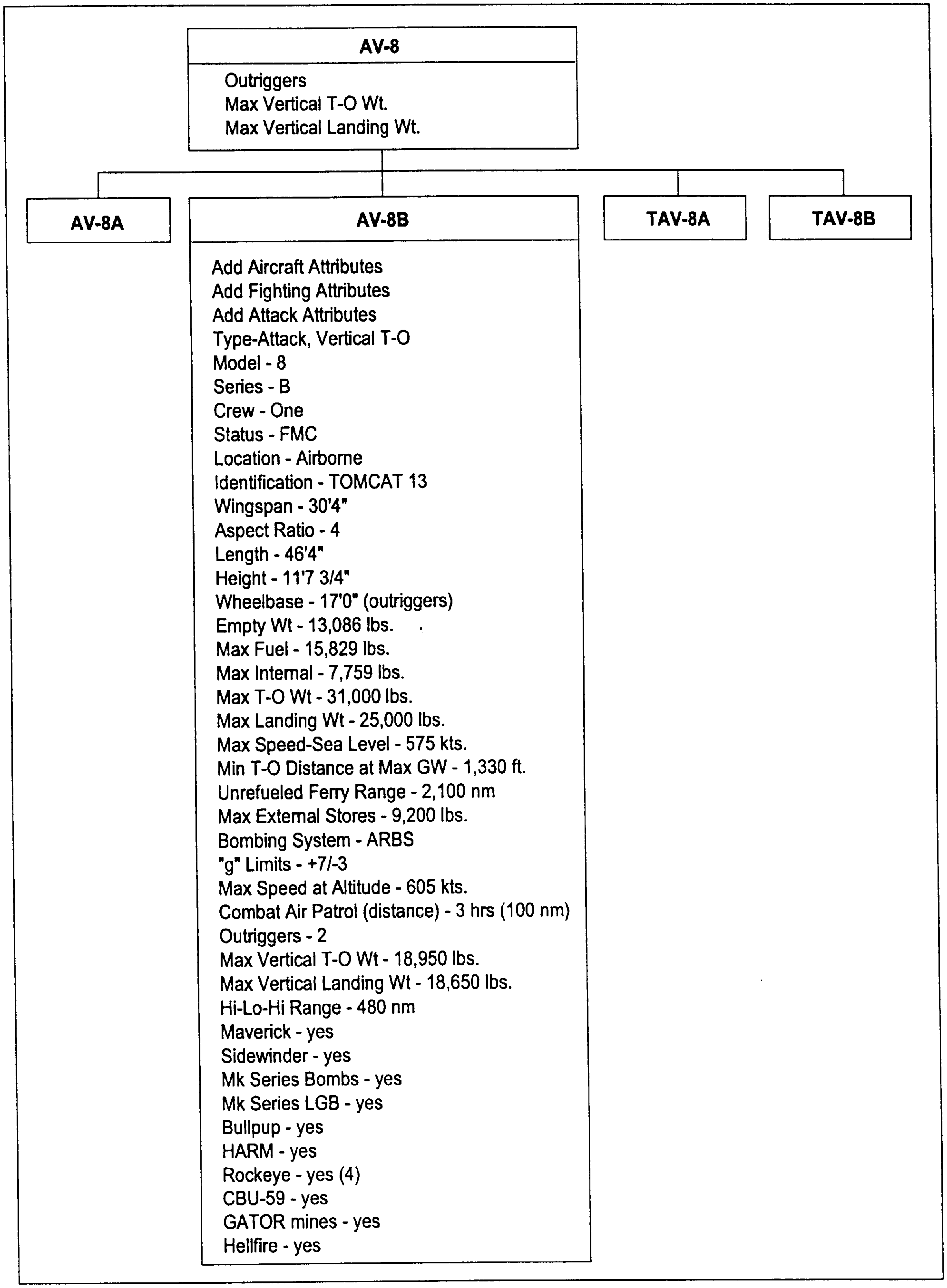


Figure B-3.10. AV-8 class attributes and AV-8B object.

Step	Physical	Agent	Event	C^2
Enemy contact	Hilltop Valley (threat) T64 tank (tracked vehicle)	U.S. Airborne Infantry Company Enemy Tank platoon Co Cdr	Daylight	Defend (mission) SOP ROE Plan Attack (mission)
Company Commander informs Bn S3	Radio A	U.S. Airborne Infantry Company U.S. Abn Inf Bn Commander S3		CoA (reporting) Situation report (SITREP) COA (asking for help)
S3 tasks FAC to request immediate CAS	Radio A Bn TOC Jeep	S3 FAC Bn Cdr U.S. Abn Inf Bn U.S. AF Combat Reporting Center (CRC)		Order SOP Task Statement
FAC formulates, issues immediate air request	Map and overlay Radio B	FAC U.S. Abn Inf Bn Bde TACP U.S. Abn Inf Bde		COA OPORD SOP Immediate air request message
Bde TACP checks resources, coordinates w/Bde S3, forwards request to Div	Radio B Map and overlay	Bde TACP U.S. Abn Inf Bde Div TACP U.S. Abn Inf Div Bde S3 Bde Cdr		OPORD SOP Immediate air request message

Figure B-4a. Object definition.

Step	Physical	Agent	Event	C^2
Div TACP checks resources, coordinates w/Div G3, forwards request to Corp	Radio B Map and overlay	Div TACP U.S. Abn Inf Div BCE U.S. XVIII Abn Corps Div G3/air		ATO SOP Immediate air request message OPORD
BCE tasks AV-8Bs	Radio B AV-8B Corps Main CP Loiter area CP	BCE Flight Cdr Wingman Marine Attack Sqdn	Move	Order Mission Stmt Control point CEOI
FAC relocates to Co Cdr	Jeep Map and overlay GPS Road	FAC U.S. Abn Inf Bn U.S. Abn Inf Co Co Cdr	Move	
FAC formulas air mission order	U.S. Abn Inf Co CP Map and overlay IP	FAC U.S. Abn Inf Bn		SOP Order
AV-8Bs reach CP, establish voice comm	Radio B	Flight leader Wingman FAC U.S. Abn Inf Bn Marine Attack Sqdn		SOP Order

Figure B-4b. Object definition.

Step	Physical	Agent	Event	C^2
FAC issues CAS mission	Radio B IP RP Route AV-8B Map and overlay	Flight leader Wingman FAC U.S. Abn Inf Bn Marine Attack Sqdn		Mission statement Order ROE
AV-8Bs perform mission	IP RP Route Radio B T64 Valley Smoke AV-8B ROCKEYE Hill Map and overlay	Flight leader Wingman Marine Attack Sqdn Enemy Tank platoon U.S. Abn Inf Co	Air-ground engagement	Report SOP COA ROE

Figure B-4c. Object definition.

Step	Physical	Agent	Event	C^2
FAC evalutes and reports BDA	Radio B Map and overlay Binoculars T64 Valley Hill Smoke	FAC U.S. Abn Inf Bn Flight leader Wingman Marine Attack Sqdn U.S. Abn Inf Co Cdr U.S. Abn Inf Bn S3		SOP Report (SITREP) CEOI
Planes go home	AV-8B Runway Air base Route Radio B	Flight leader Wingman Marine Attack Sqdn BCE Marine DASC Marine MASS Marine TAOC Marine MACS	Move	SOP CEOI Report (INFLTREP)

Figure B-4d. Object definition.

APPENDIX C:
SAMPLE OBJECT TANK

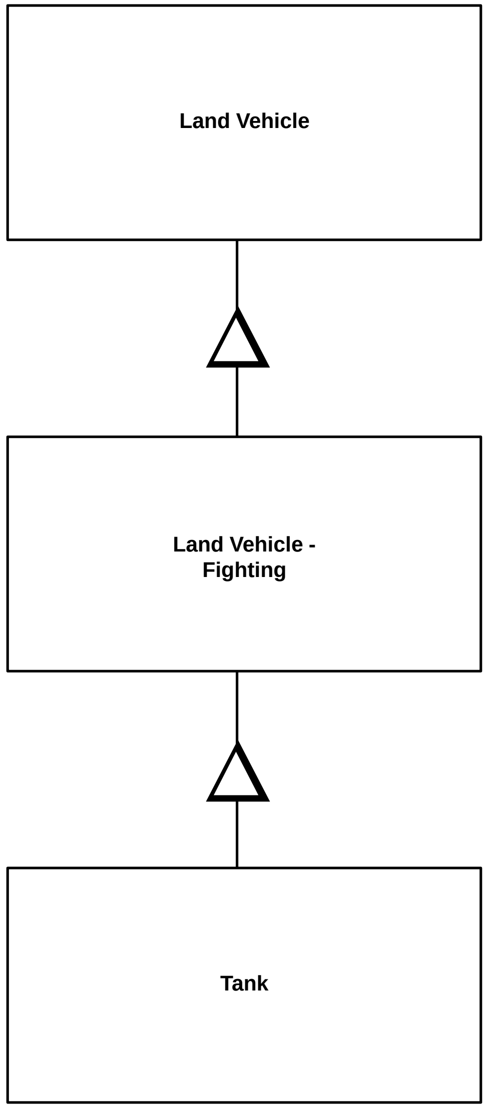


Figure C-1. Class inheritance for sample object – tank.

Land Vehicle	
Identity	Weight_Combat
Country_Origin	GroundPressure
Country_Operation	Max_Roadspeed
Make	Max_CrossCountrySpeed
Model	Max_FordingDepth_Prepared
LIN #	Max_FordingDepth_Unprepared
Year_Manufacture	Type_FordingEquipment
Status	Max_VerticleObstacleHeight
Location	Max_WidthTrench
Destination	Engine_Type
Range_Average	Engine_Location
Range_Extended	Engine_NumberCylinders
Speed	Engine_Horsepower
Direction	Ratio_HorsepowerToWeight
Type_Armor	Transmission_Type
Location_Armor	Steering_Type
Thickness_Armor	Suspension_Type
Armament_Type	Navigation_Type
MobilitySystem_Type	VisionSystem_Type
Axles_Number	Radius_Turning
Axles_Location	Acceleration_0–60
Wheels_Number	Acceleration_Qtrmile
Wheels_Location	Amphibious
Bogiewheels_Number	AmphibiousDrive_Type
Bogiewheels_Location	Electrical_System
Trailingwheels_Number	Communications_System
Trailingwheels_Location	MobilityGear_Spare
Guidewheels_Number	Toolkit
Guidewheels_Location	MaxPercent_Slope
Drivewheels_Number	MaxPercent_Gradient
Drivewheels_Location	Associated_PrimeMover
Articulated_Vehicle	Associated_Trailer
Crew_Type	Guidance_RemoteControlled
Crew_Number	Associated_Photo
Fuel_Type	Associated_OperatingManual
Fuel_Capacity	Associated_MaintenanceManual
Body_Length	Associated_TacticalManual
Body_Weight	CollectiveNBCSys
Body_Width_Skirts	Vismod_Type
Body_Height	SmokeSystem_Type
GroundClearance	IFF_Type
Tires_Width	CamouflageSchema_Type
Track_Width	CenterOfGravity_Empty
Track_LengthOnGround	CenterOfGravity_Loaded
Weight_Unloaded	Color

Tank
Type_Hull
Location_MainGun_AmmoStowage
Type_Loader

Land Vehicle – Fighting
Type_Configuration
MissionArea
Type_WpnsSystem_Main
Purpose_WpnsSystem_Main
MaxElevation_WpnsSystem_Main
MinDepression_WpnsSystem_Main
Traverse_WpnsSystem_Main
PositionOnVehicle_WpnsSystem_Main
TypeAmmunition_WpnsSystem_Main
APFSDS
HEAT–FS
HED–T
HE–FRAG
Smoke
QtyAmmunition_WpnsSystem_Main
Type_WpnsSystem_Secondary
Purpose_WpnsSystem_Secondary
MaxElevation_WpnsSystem_Secondary
MinDepression_WnpsSystem_Secondary
Traverse_WpnsSystem_Secondary
PositionOnVehicle_WpnsSystem_Secondary
TypeAmmunition_WpnsSystem_Secondary
QtyAmmunition_WpnsSystem_Secondary
Type_WpnsSystem_Tertiary
Purpose_WpnsSystem_Tertiary
Max_Elev_WpnsSystem_Tertiary
Min_Depression_WpnsSystem_Tertiary
Traverse_WpnsSystem_Tertiary
PositionOnVehicle_WpnsSystem_Tertiary
Type_Ammunition_WpnsSystem_Tertiary
Qty_Ammunition_WpnsSystem_Tertiary
SmokeLaying
Thickness_Armor_FrontUpper
Thickness_Armor_FrontLower
Thickness_Armor_SideUpper
Thickness_Armor_SideLower
Thickness_Armor_RearUpper
Thickness_Armor_RearLower
Thickness_Armor_TopTurret
Thickness_Armor_TopHull
Thickness_Armor_BellyFront
Thickness_Armor_BellyRear
Thickness_Armor_TurretFront
Thickness_Armor_TurretSide
Type_CollectiveNBCProtectionSystem
FireControlSystem
FireSuppressionSystem
FireControlSystemController
Glacis_Front_Upper
Glacis_Front_Lower
Glacis_Side_Upper
Glacis_Side_Lower
Glacis_Rear_Upper
Glacis_Rear_Lower

VIRTUAL FUNCTION PSEUDOCODE AND SAMPLE IDL

Pseudocode and IDL are shown for the Tank class. The Tank pseudocode shows how different degrees of resolution can be supported by polymorphism (see Tank: Initialize). It also demonstrates how a good deal of JWSOL object content can be abstracted away from simulation engine specifics (see Tank: Move). (Simulation engine is a generic term referring to the computational infrastructure and specific implementation choices that instantiate a model or simulation. Normally, "simulation engine" is used to distinguish computational elements from the simulation content, i.e., the model of real–world phenomena.) Minimizing simulation engine dependencies is important for a general–purpose object repository.

There are five virtual functions below: Initialize, Assign, Move, Fire, and ReceiveFire.

Tank: Initialize

Create a tank object and set up its initial state

Create Tank object
Case Resolution
"Coarse"
    (initialize a subset of the attributes from the "Fine" resolution below)
"Medium"
    (as w/ Coarse)
"Fine"
    Location
    Identity
    Country_Origin
    Country_Operation
    Make
    Model
    LIN#
    Year_Manufacture
    Status
    Destination
    Range_Average
    Range_Extended
    Speed
    Direction
    Type_Armor
    Location_Armor
    Thickness_Armor
    Armament_Type
    Type_Armor
    Location_Armor
    Thickness_Armor
    Armament_Type

Mobility_System_Type
Axles_Location
Wheels_Number
Wheels_Location
Bogiewheels_Number
Bogiewheels_Location
Trailingwheels_Number
Trailingwheels_Location
Guidewheels_Number
Guidewheels_Location
Drivewheels_Number
Drivewheels_Location
Articulated_Vehicle
Crew_Type
Crew_Number
Fuel_Type
Fuel_Capacity
Body_Length
Body_Weight
Body_Width_Skirts
Body_Height
GroundClearance
Tires_Width
Track_Width
Track_LengthOnGround
Weight_Unloaded
Weight_Combat
GroundPressure
Max_RoadSpeed
Max_CrossCountrySpeed
Max_FordingDepth_Prepared
Max_FordingDepth_Unprepared
Type_FordingEquipment
Max_VehicleObstacleHeight
Engine_NumberCylinders
Engine_Horsepower
Ratio_HorsepowerToWeight
Transmission_Type
Steering_Type
Suspension_Type
Navigation_Type
VisionSystem_Type
Radius_Turning

Acceleration_0–60
Acceleration_Qtmile
Amphibious
AmphibiousDrive_Type
Electrical_System
Communications_System
MobilityGear_Spare
Toolkit
MaxPercent_Slope
MaxPercent_Gradient
Associated_PrimeMover
Associated_Trailer
Guidance_RemoteControlled
Associated_Photo
Associated_OperatingManual
Associated_MaintenanceManual
Associated_TacticalManual
CollectiveNBCSys
Vismod_Type
SmokeSystem_Type
IFF_Type
CamouflageSchema_Type
CenterOfGravity_Empty
CenterOfGravity_Loaded
Color
Type_Configuration
MissionArea
Type_WpnsSystem_Main
Purpose_WpnsSystem_Main
MaxElevation_WpnsSystem_Main
MinDepression_WpnsSystem_Main
Max_WidthTrench
Engine_Type
Engine_Location
Traverse_WpnsSystem_Main
PositionOnVehicle_WpnsSystem_Main
TypeAmmunition_WpnsSystem_Main
- *APFSDS*
- *HEAT–FS*
- *HED–T*
- *HE–FRAG*

QtyAmmunition_WpnsSystem_Main
Type_WpnsSystem_Secondary

Purpose_WpnsSystem_Secondary
MaxElevation_WpnsSystem_Secondary
MinDepression_WpnsSystem_Secondary
Traverse_WpnsSystem_Secondary
PositionOnVehicle_WpnsSystem_Secondary
TypeAmmunition_WpnsSystem_Secondary
QtyAmmunition_WpnsSystem_Secondary
Type_WpnsSystem_Tertiary
Purpose_WpnsSystem_Tertiary
MaxElevation_WpnsSystem_Tertiary
MinDepression_WpnsSystem_Tertiary
Traverse_WpnsSystem_Tertiary
PositionOnVehicle_WpnsSystem_Tertiary
TypeAmmunition_WpnsSystem_Tertiary
QtyAmmunition_WpnsSystem_Tertiary
SmokeLayering
Thickness_Armor_FrontUpper
Thickness_Armor_FrontLower
Thickness_Armor_SideUpper
Thickness_Armor_SideLower
Thickness_Armor_RearUpper
Thickness_Armor_RearLower
Thickness_Armor_TopTurret
Thickness_Armor_TopHull
Thickness_Armor_BellyFront
Thickness_Armor_Bellyrear
Thickness_Armor_TurretFront
Thickness_Armor_TurretSide
Type_CollectiveNBCProtectionSystem
FireControlSystem
FireSuppressionSystem
FireControlSystemController
Glacis_Front_Upper
Glacis_Front_Lower
Glacis_Side_Upper
Glacis_Side_Lower
Glacis_Rear_Upper
Glacis_Rear_Lower
Type_Hull
Location_MainGun_AmmoStorage
Type_Loader

End Tank: Initialize

Tank: Assign

Make an association between a Tank and a Tank Platoon, or a Tank and an Engagement

If Class_Type (input) is Engagement
  Set "Engaged" to (input)
Else if Class_Type (input) is Military_Organization
  Set "Assigned–To" to (input)

End Tank: Assign

Tank: Fire

Fire on OPFOR

If Status (self) is "Operational"
  Get OPFOR Target and Location from own "Assigned–To" Military_Organization object
  Calculate visibility, targetability
  If Ammo_Store NotEqual "empty"
  And Time (now) – Time_of_Last_Fire is "Enough"
    If Resolution is "Coarse" or "Medium"
      Send "Fire from (Tank type)" message to OPFOR target
    Else
      Send "Fire from (pointer to Munition object)" message
        to OPFOR target
  Set Time_of_Last_Fire is Time (now)
  Send (self) Fire msg.

End Tank: Fire

Tank: Move

Move from one Location to another

If Status (self) is not "Operational" Or "Mobile"
Send owner Org. "Update Status (self ID)" msg.
Send Move "Purge all 'Arrive Time/Location ' msg.'s for (self ID)"
Else
Set Destination to input Location
If Location (self) is same as Destination
Send owner Org. "Arrived (self ID, Location)" msg.
Else
Plot route vis–a–vis simulation spatial representation
If POL (i.e., fuel) is not adequate
Report problem to owner Org.
Else
If Resolution is "Coarse"
Send Move obj. "Arrive (self ID) Time/Location" msg.
Else (Resolution is "Medium" or "Fine")
Build movement conditions profile
Query Precipitation objects on route
Query Surface_Cover objects on route
If Surface_Cover is impassable
And (no mediation, e.g., Bridges over River)
Report problem to owner Org. & Exit
Query Obstacle objects on route
If Obstacle is impassable
Report problem to owner Org. & Exit
Query Env._Phenom. objects on route
If Env. is impassable (e.g., flood, hurricane, etc.)
Report problem to owner Org. & Exit
Build topographical profile
Query Topography objects on route
Add increment to topographical profile
If Topography is impassable
Report problem to owner Org. & Exit
Calculate movement time: point–to–point on route
Send Move (event object) series of "Arrive (self ID)
Time/Location (self)" messages

End Tank: Move

Tank: Receive Fire

Receives fire (default is from OPFOR, although could be specialized to also receive fire from friendlies if a simulation needed to model such events).

If Status (self) is "Operational"

Translate incoming fire to resolution–independent form

Assesses self–damage:

Case Kind of fire

Rockeye	*Set Status (self) = "Destroyed"*
M1A1 Cannon	*Set Status (self) = "Destroyed"*
etc.	

End case

Send own "Assigned–To" Military_Organization object "Update Status" msg., with ID (self)

End Tank: Receive Fire

More detail could be developed for the virtual function pseudocode above if a particular modeling need called for it. For example, in Tank: Move, calculation of movement through obstacles could use Body_Length, Body_Height, Body_Width, Weight_Combat, Track_LengthOnGround, Max_Vertical–ObstacleHeight, Max_WidthTrench, etc. Similarly, Tank: ReceiveFire could use details on armor, location of hit, specific munition, etc., to determine degree of damage.

The Tank Interface Definition Language (IDL) specification follows.

```
// ************************************************************
//
//     Tank interface specification (sample)
//
// ************************************************************
// ************************************************************

typedef    string Resolution;// "Coarse", "Medium", "Fine"
typedef    long   Coordinate;// x, y, & poss. z
typedef    sequence <Coordinate> Location;

interface Tank {

    exception Tank_Invalid_Init();
    exception Tank_Invalid_Assignment();
    exception Tank_Invalid_StatusRequest();
    exception Tank_Invalid_Mission();

    // Tank: Initialize
    // Receives Resolution, Location, and poss. the AgentID
    // for the Mil._Org. to which it is assigned
    // Provides own ID, Status to owner Mil._Org.if possible
    void Tank_Initialize (
      in    string     Resolution,
      in    Location   CurrrentLocation,
      in    AgentID      Assigned_To,// If the AgentID is not of
                                 // correct type, raise
                                 // exception
      out FightVehicleID   selfID, // Send if AgentID in call
      out string     Status     // Send if AgentID in call
      )
      raises (Tank_Invalid_Init);
```

```
// Receives Resolution, requestor ID
    // Provides Status, Location, and (according to
    // Resolution) many, many other attribute values
    void Tank_Status (
      in     string     Resolution,
      in     AgentID      Requestor,   // If AgentID is not valid
                                 // requestor, raise exception
      in   string     attributeSpecifier, // if null, selfID and

                                 // Status only
      out  FightVehicleID    selfID,
      out  string     Status,
      out  AtrToken   attributeValue  // content will
                                 // vary according to input
                                 // AttributeSpecifier

      )
      raises (Tank_Invalid_StatusRequest);

    // Receives the AgentID for the Mil._Org. to which it is
    // assigned, or Engagement type (Gnd_Gnd,Gnd_Air,
    // Gnd_Surface, Gnd_Space,Air_Gnd,Surf_Gnd, Subsurf_Gnd)
    // Provides own ID, Status to owner Mil._Org.if possible
    void Tank_Assign (
      in     AgentID    Assigned_To, // If bad AgentID, raise
                               // exception
      in     EventID    Engaged,     // If bad EventID, raise
                               // exception
      out  FightVehicleID    selfID,  // return selfID and Status
      out  string   Status,         // if Agent assignment
      )
      raises (Tank_Invalid_Assignment);
    // Receives Resolution, destination Location, AgentID for
    // Mil._Org. to which it is assigned.
    // Provides Location_@_Time, Status
    void Tank_Move (
      in     string     Resolution,
      in     Location   Destination,
      in   AgentID    CommandSource,  // If CmndSource not same
                                   // as Assigned_To or superior
                                   // to, raise exception
      out  FightVehicleID    selfID,
      out  string     Status,
      out  short      Time,
      out  Location   CurrrentLocation //
      )
      raises (Tank_Invalid_Assignment);
```

```
// Receives Resolution, OPFOR target ID, and OPFOR Location
    // Provides WeaponType, and “Fire” or “Fire from” plus
    // munitions ID to target
    void Tank_Fire (
      in     string     Resolution,
      in   AgentID    CommandSource,  // If CmndSource not same
                                      // as Assigned_To or superior
                                      // to, raise “Assign” excptn
      in     AgentID    Target_Agent,     // Only one of Agent and
      in     PhysicalID Target_Physical,// Phys. will be non–null
                                      // If Target is not valid
                                      // type re: MissionArea,
                                      // raise “Mission” excptn
      in     Location   Target_Location,
      out  string     Type_WpnsSystem,// “Main”, “Secondary”, or
                                      // “Tertiary”, as app.
      out  string     Type_Munition   // Sent if Res. = med or fine
      )
      raises (Tank_Invalid_Assignment, Tank_Invalid_Mission);


    // Receives WeaponType, and either “Fire” or “Fire from”
    // plus munitions ID
    // Provides Status to he Mil._Org. to which it is
    // assigned, also poss. to its curent Engagement object
    void Tank_ReceiveFire (
      in     string     Resolution,
      in     string     Type_WpnsSystem,  // Phys. will be non–null
      in   string       Type_Munition     // If Res. = med or fine
      out  FightVehicleID    selfID,
      out  string       Status
      );
```

APPENDIX D:
SAMPLE STATE AND DATA FLOW DIAGRAMS

Appendix D: Figures

Forward Air Controller (Airborne)

Forward Air Controller

Close Air Support

Weapons

Organization

Military

Forward Air Controller (Airborne) (FAC) (A)

C^2

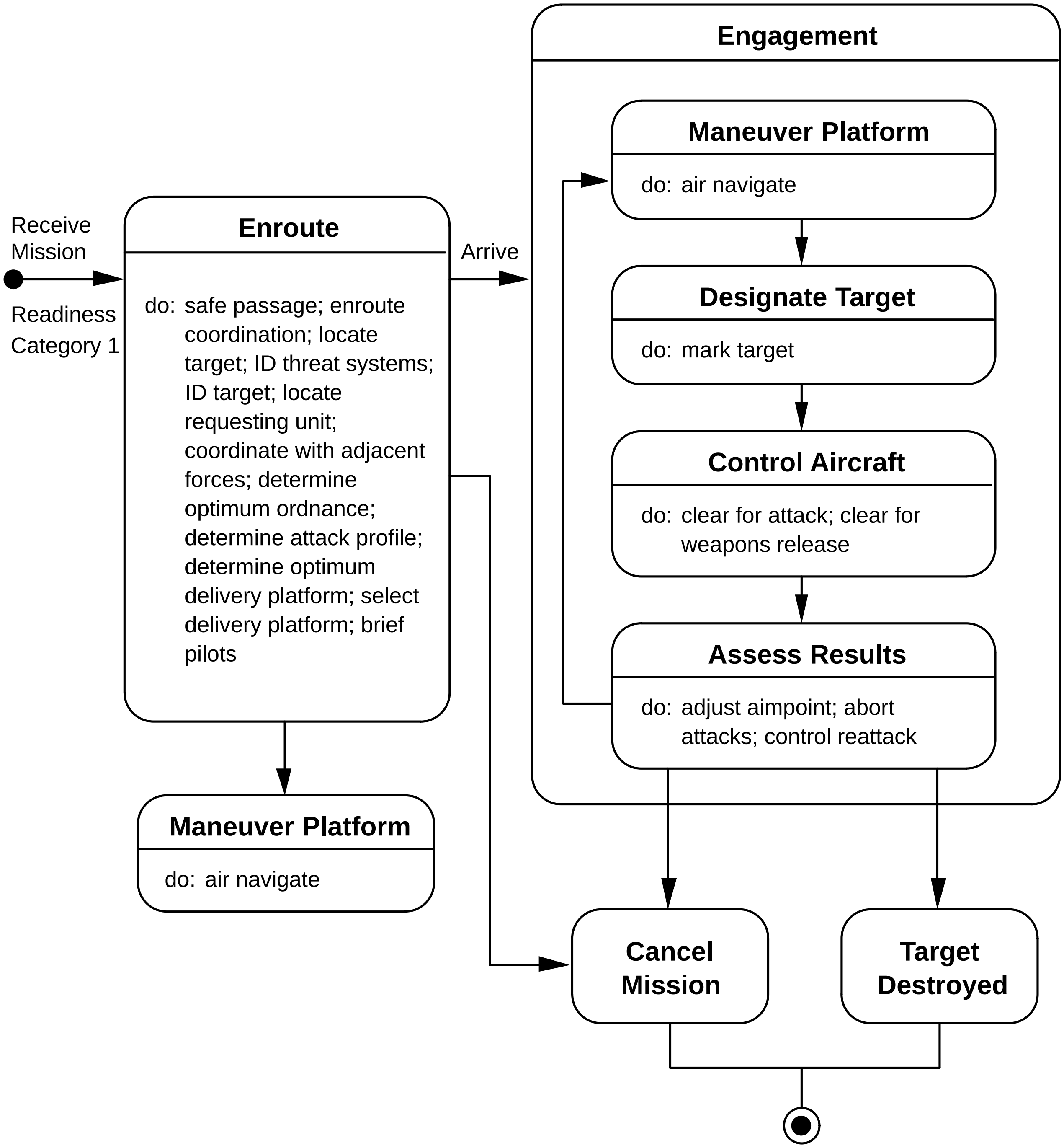
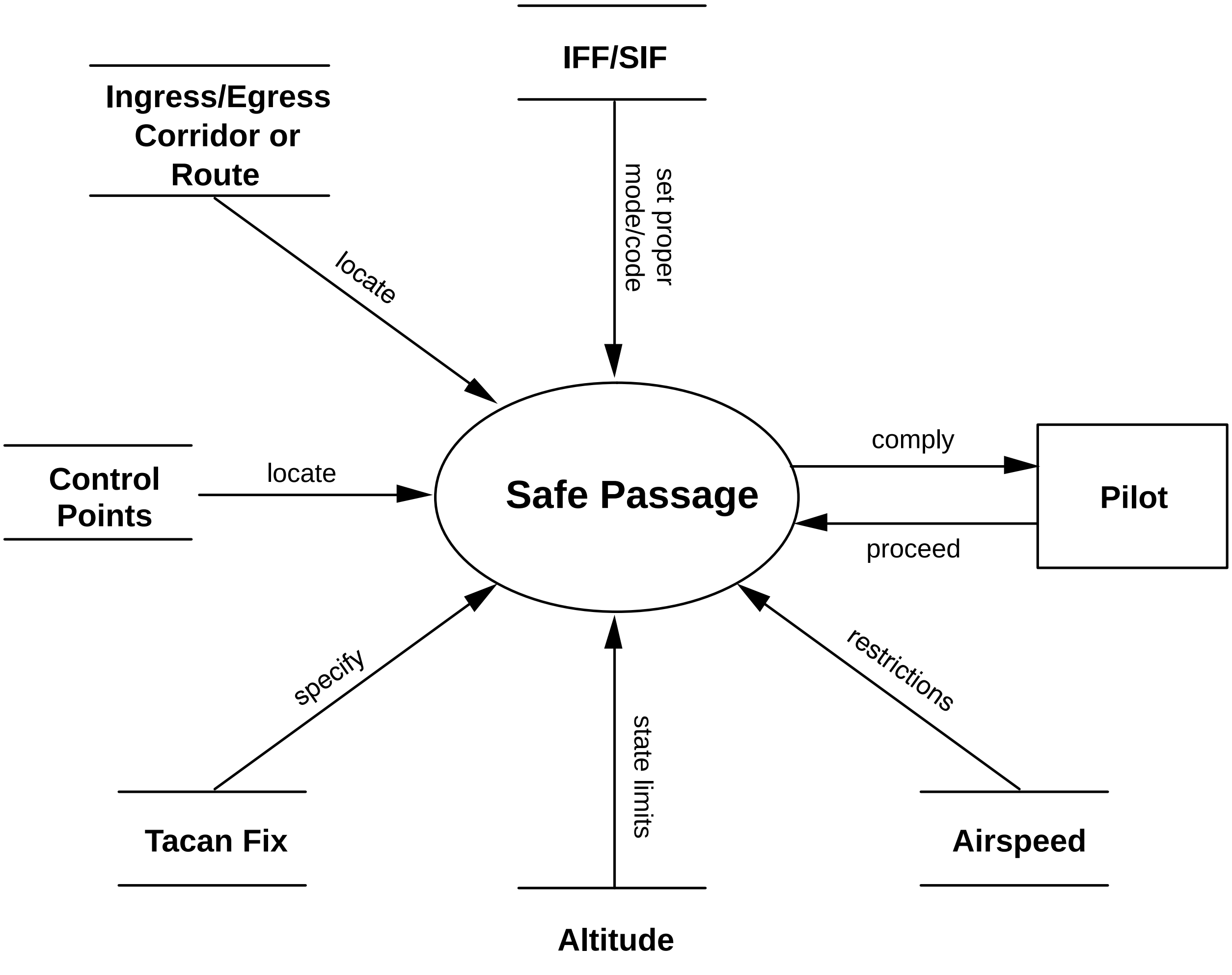
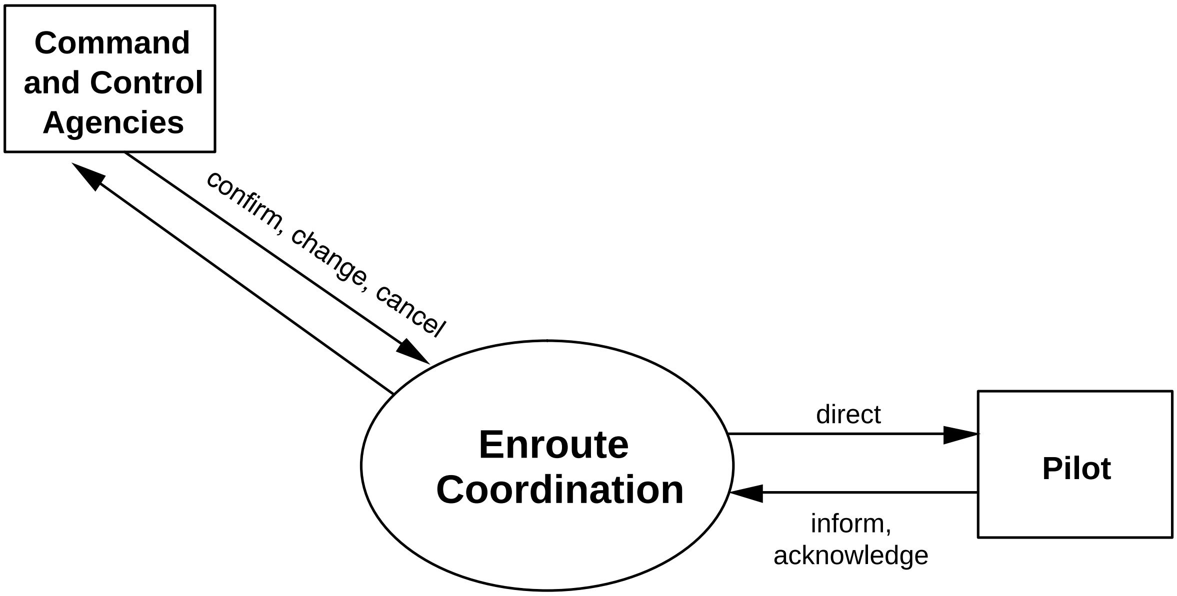


Figure D-1. State diagram for the mission of Forward Air Controller (Airborne) FAC(A).



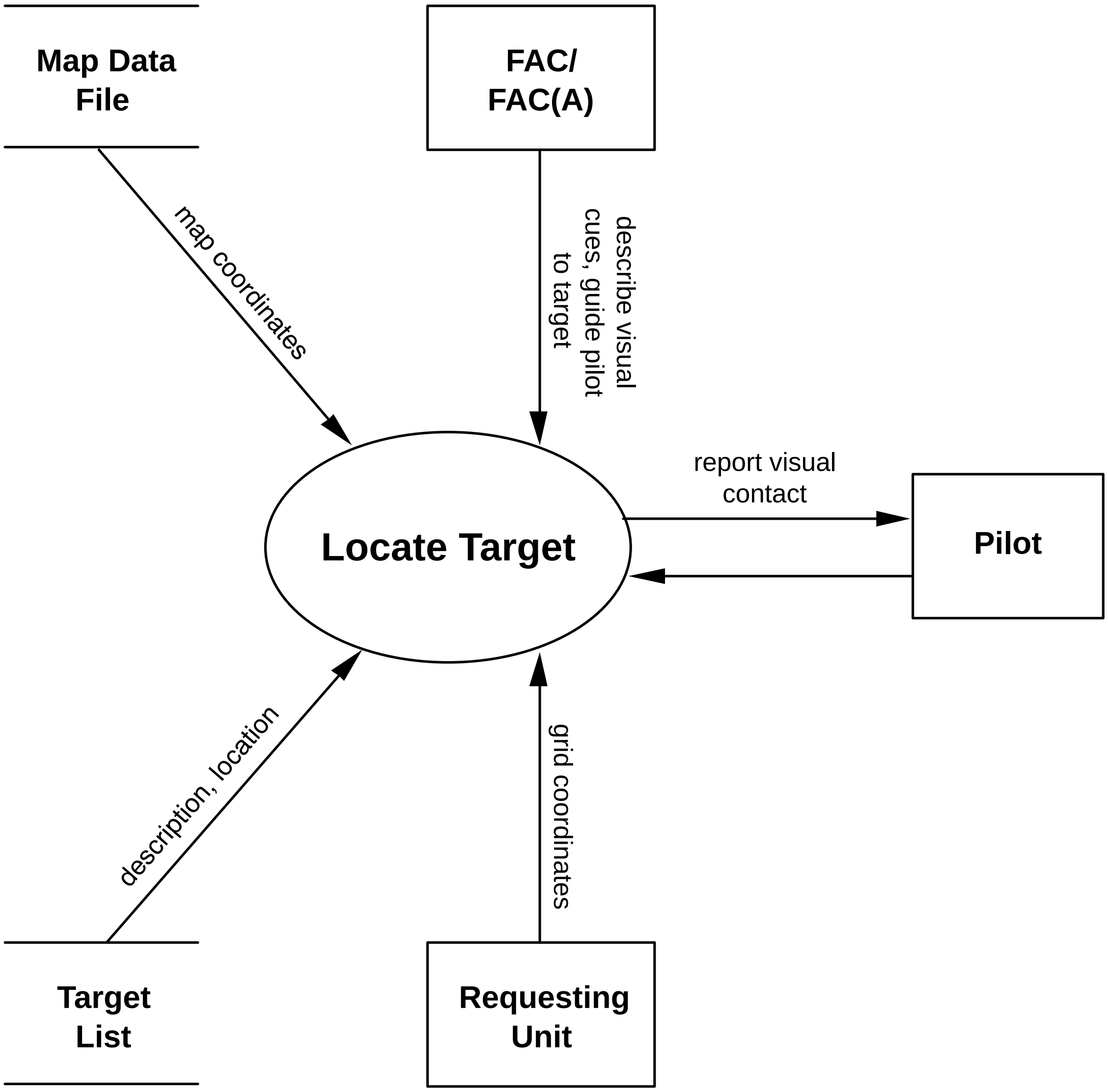
Note: Ingress/Egress/Return to Force (RTF) procedures must be followed in exacting detail. Any and/or all listed must be followed to avoid fratricide and maximize the safety of the defended area.

Figure D-2. Data flow diagram for Safe Passage state.



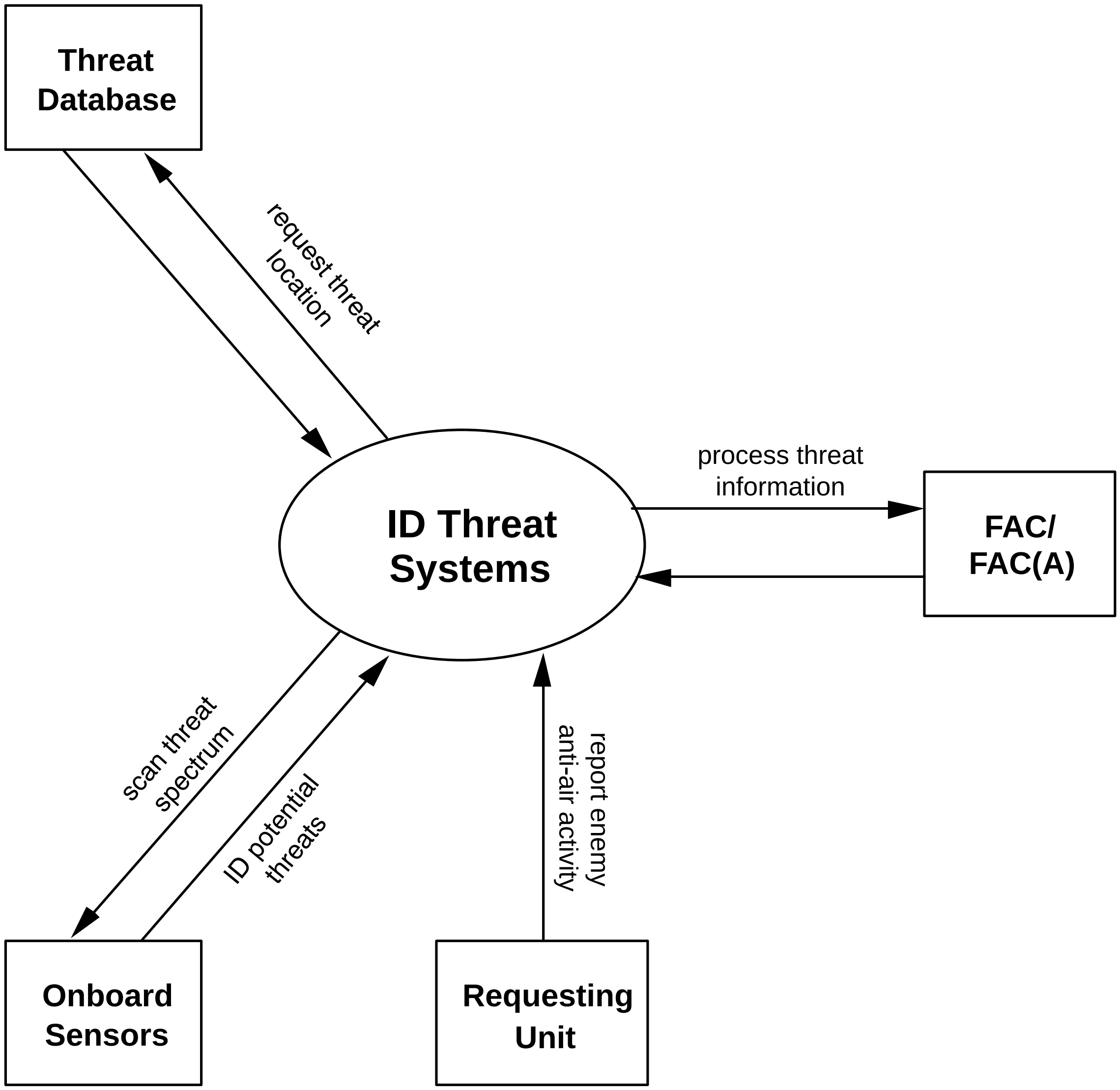
Note: Command and control agency names vary depending on combined, unified, and/or service doctrine. They may include air control, air defense, and air support agencies.

Figure D-3. Data flow diagram for Enroute Coordination state.



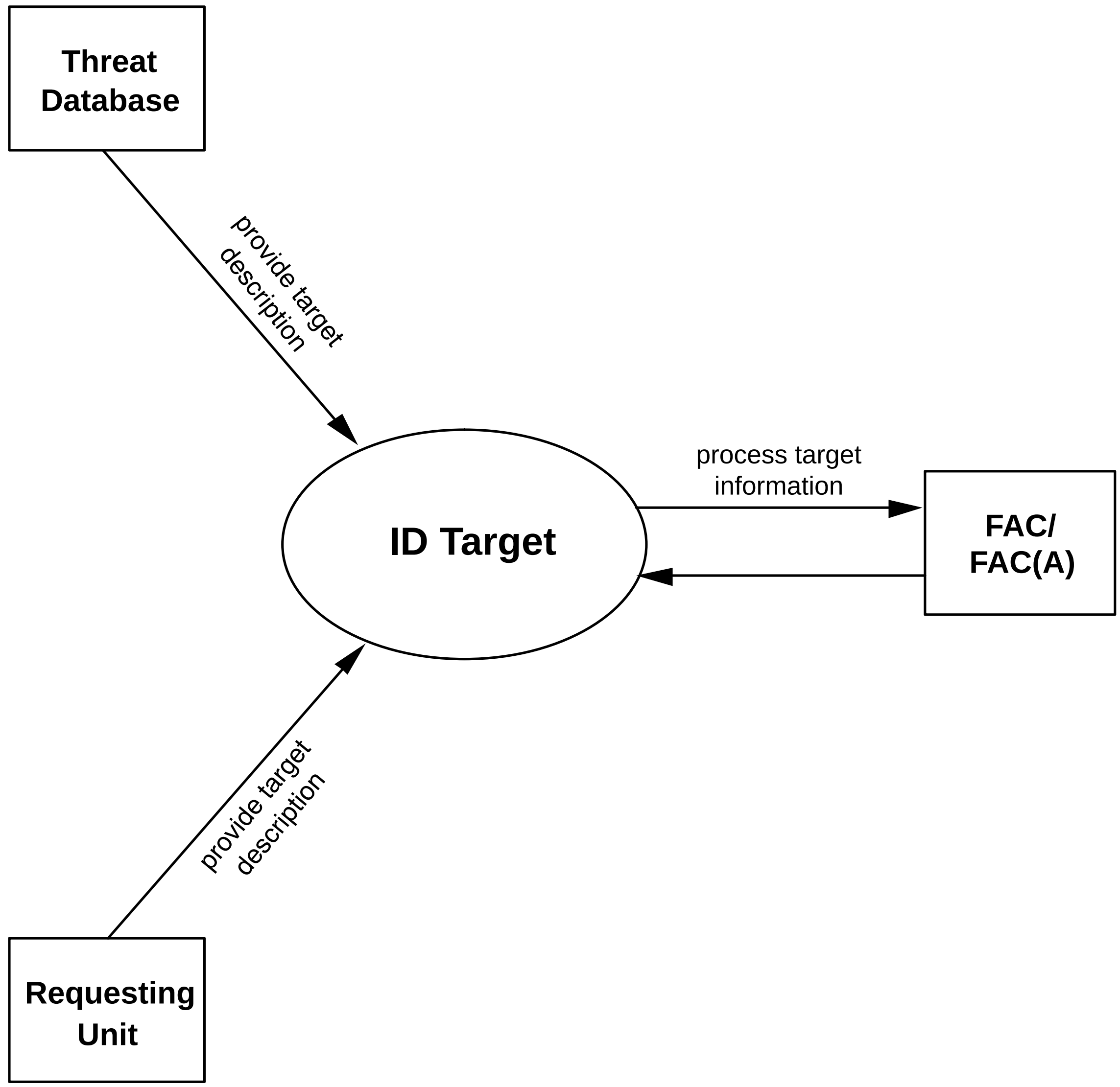
Note: Aggregate of the data stores to locate target or target area. FAC will describe the cues that will eventually focus the pilot's attention on the target, or the immediate target area. For example, he may start with 2 kilometers north of x and y road intersection, followed by 100 meters west of the white church.

Figure D-4. Data flow diagram for Locate Target state.



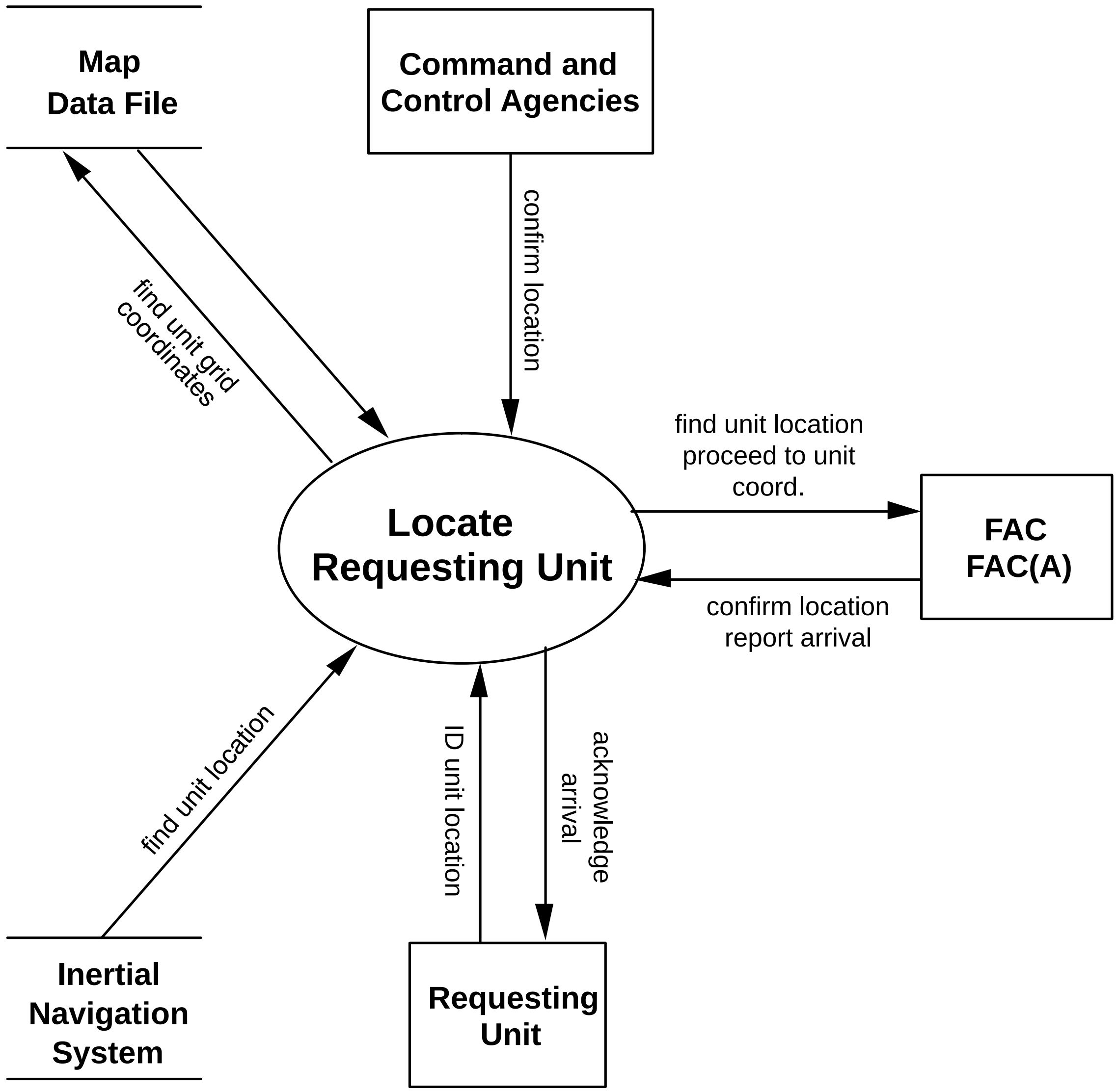
Note: Prior to entering the target area, it is important to know if there are threats that could shoot you and/or supporting aircraft down. The Threat Database will provide detailed and accurate information on fixed sites. On-board sensors are used to determine if these fixed sites are active and is the first indicator of mobile systems.

Figure D-5. Data flow diagram for ID Threat Systems state.



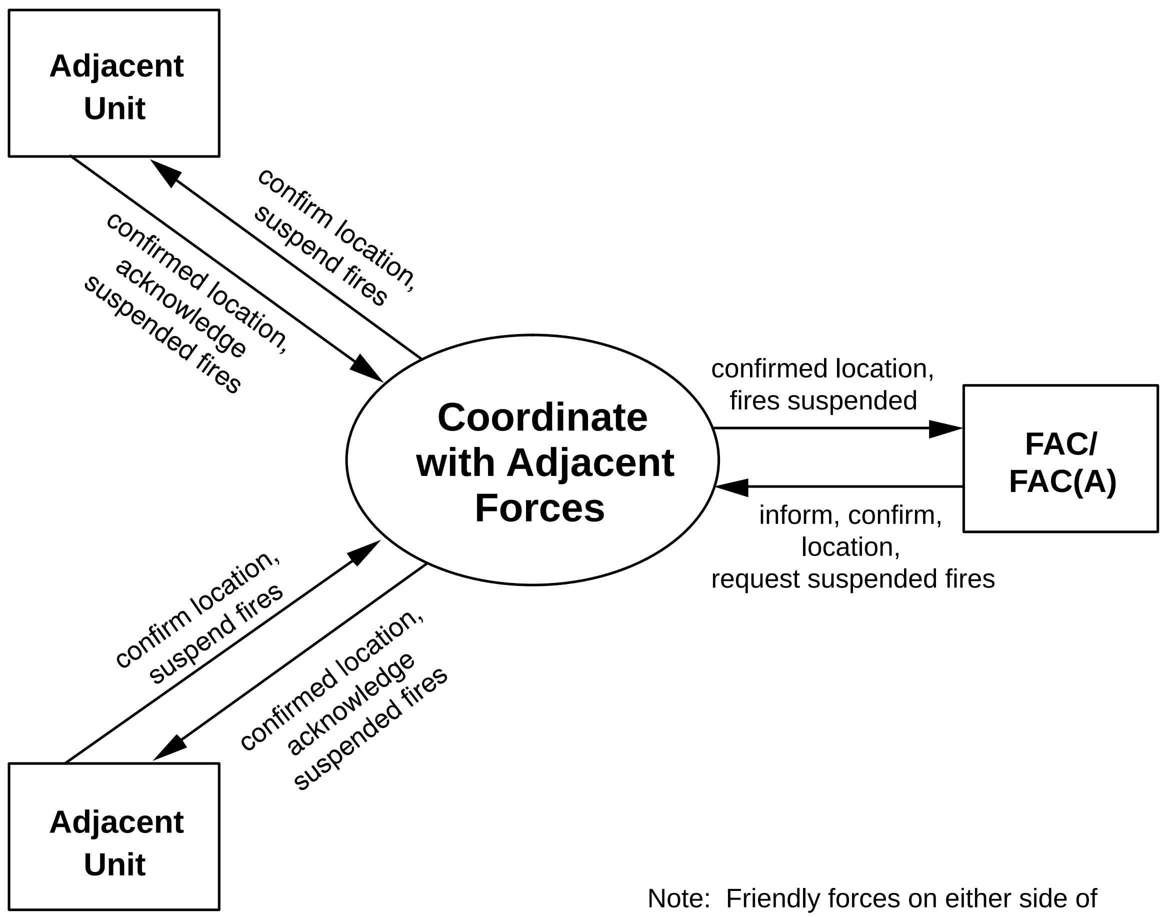
Note: Target Database can provide precise locating information, but more normally, the unit requesting the CAS will provide precise target ID.

Figure D-6. Data flow diagram for ID Target state.



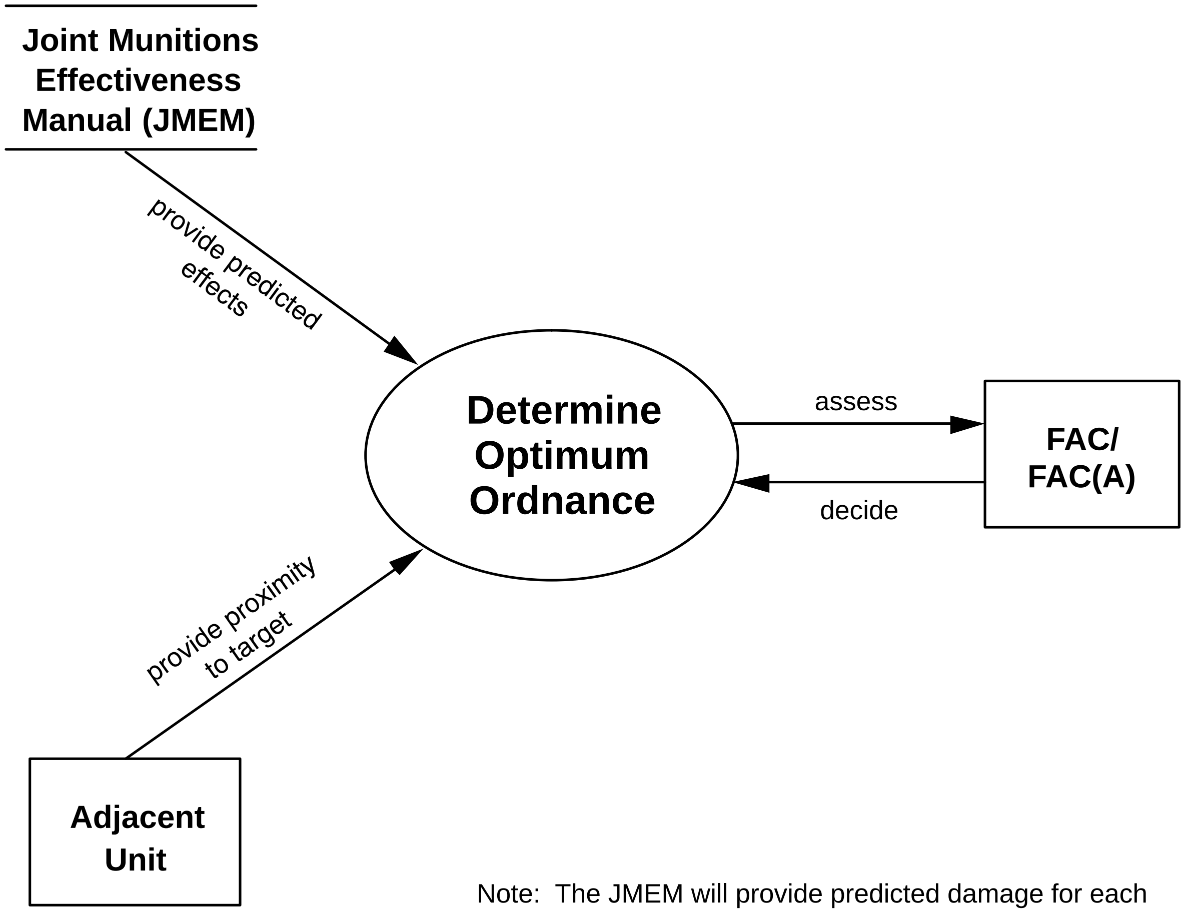
Note: Any, and/or all of the action/data stores could be used to find/confirm where the requesting unit is actually located.

Figure D-7. Data flow diagram for Locate Requesting Unit state.



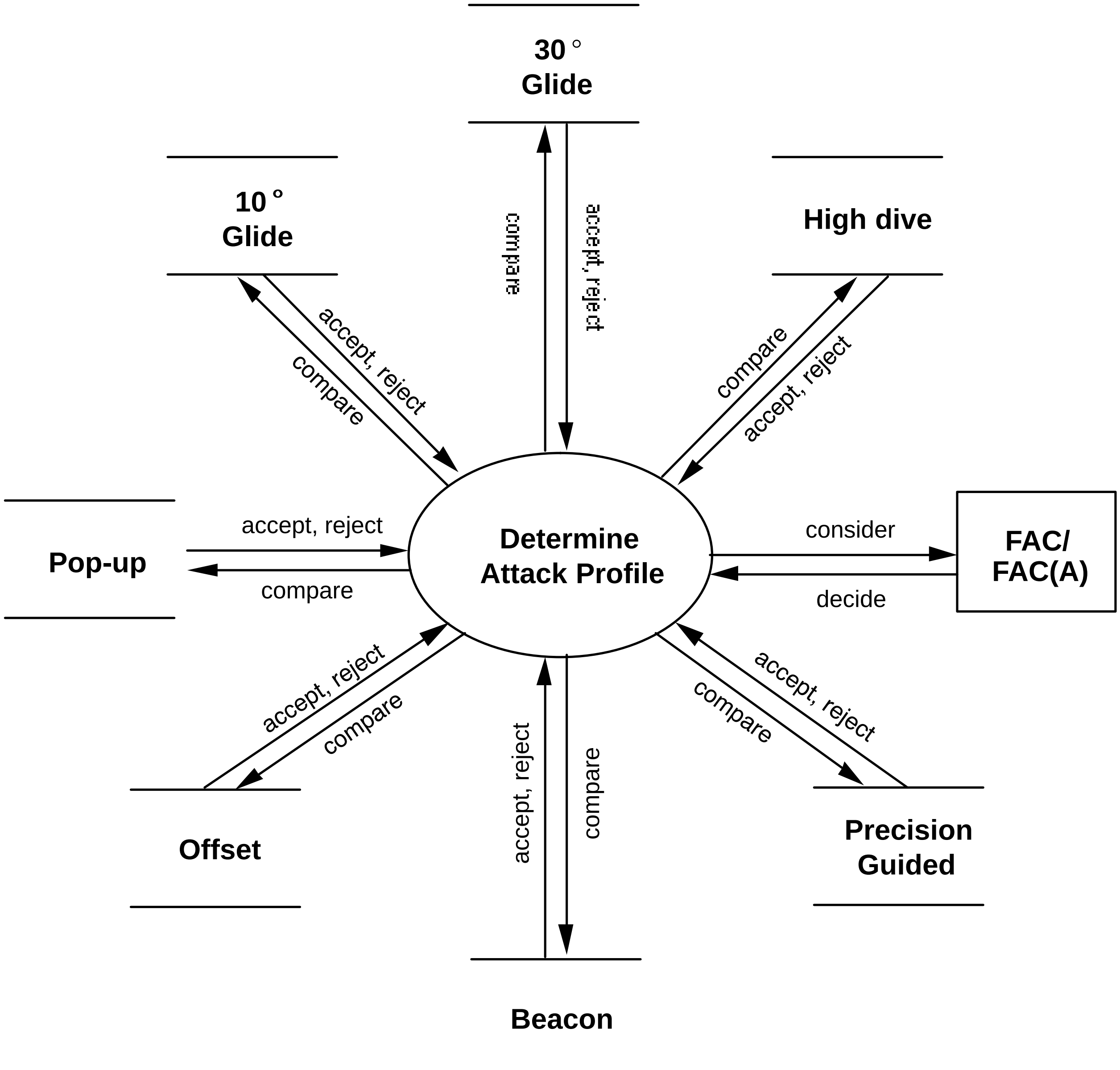
Note: Friendly forces on either side of requesting unit must be made aware of the mission, and any mortar/artillery fires that could hit the aircraft must be suspended. The FAC must also ensure that he knows where these units are located to avoid friendly fire casualties.

Figure D-8. Data flow diagram for Coordinate with Adjacent Forces state.



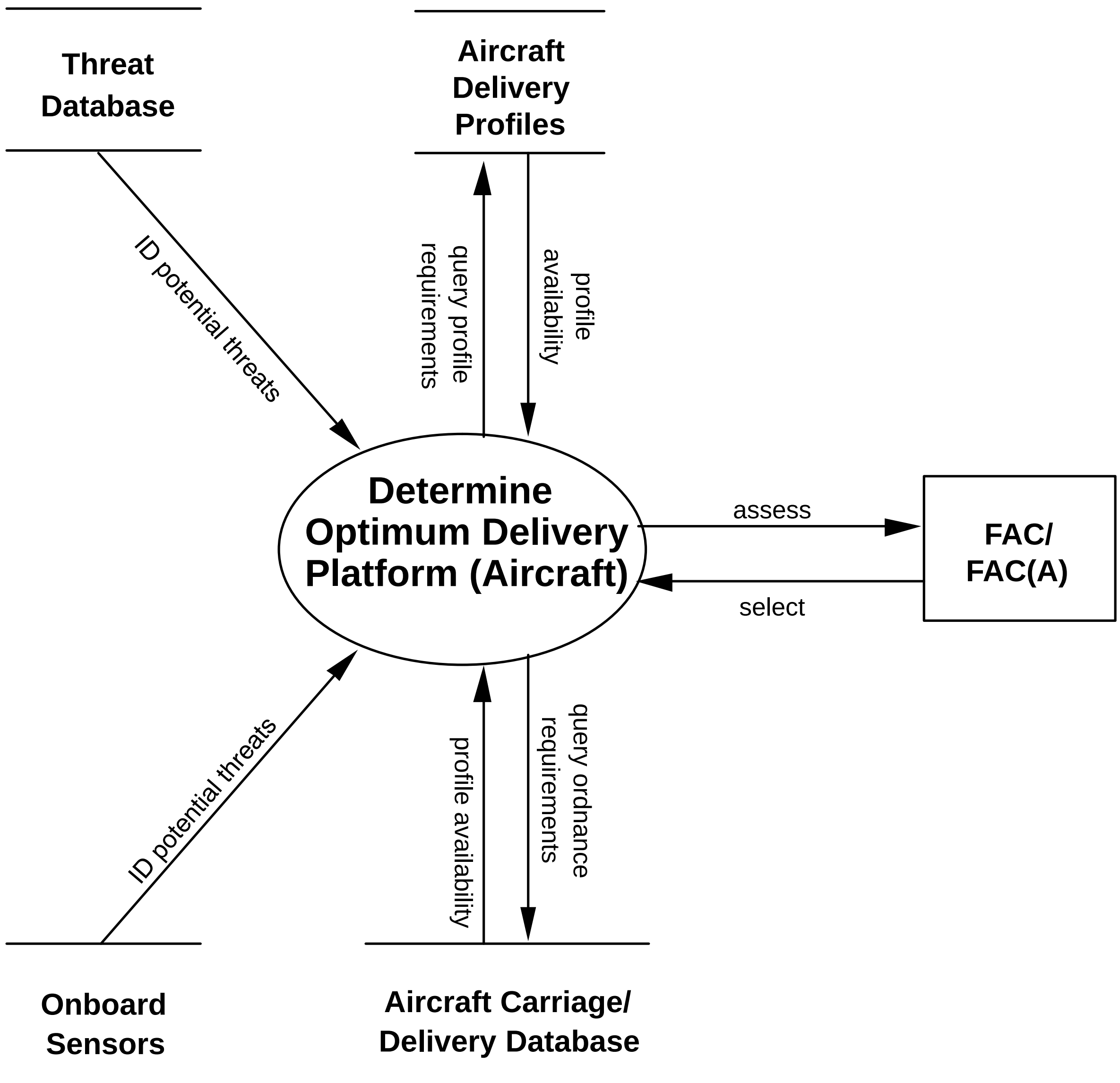
Note: The JMEM will provide predicted damage for each available weapon and the numbers of each kind required to destroy/damage the target. Requesting unit notifies the FAC how close he is to the target. For example, the best ordnance to destroy the target may have a damage radius that would pose a (serious) danger for friendly forces. In such a case, another kind of ordnance may be chosen unless the threat warrants the danger to friendlies.

Figure D-9. Data flow diagram for Determine Optimum Ordnance state.



Note: It is not appropriate to discuss the factors that weight the decision. Important are the trade-offs in accuracy (lethality) and survivability. Tables are available that compare these factors.

Figure D-10. Data flow diagram for Determine Attack Profile state.



Note: The FAC queries the data stores described to determine: (1) the best delivery system; (2) can the best system carry and deliver the optimum ordnance and fly the profile dictated by the threat.

Figure D-11. Data flow diagram for Determine Optimum Delivery Platform state.

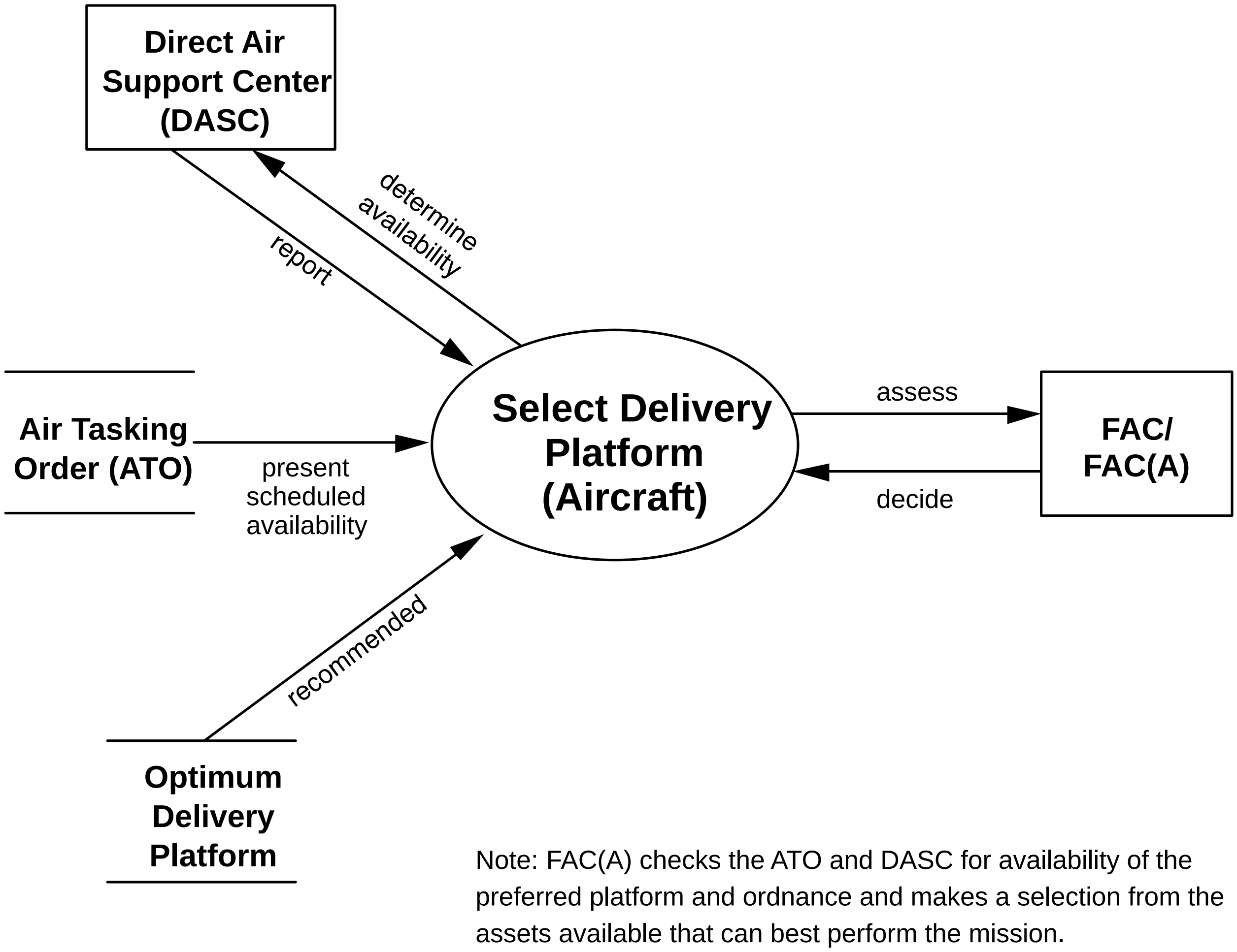
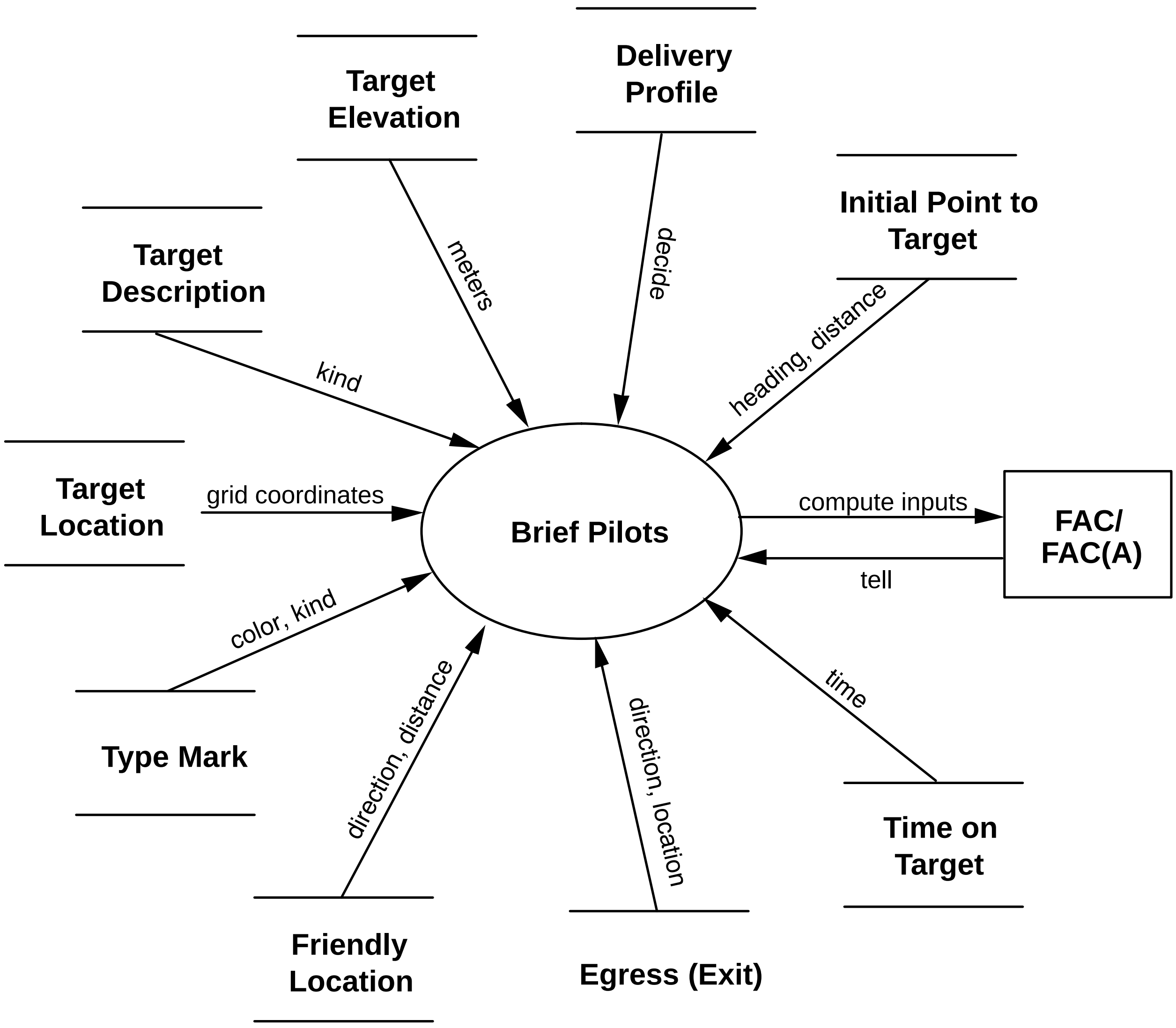
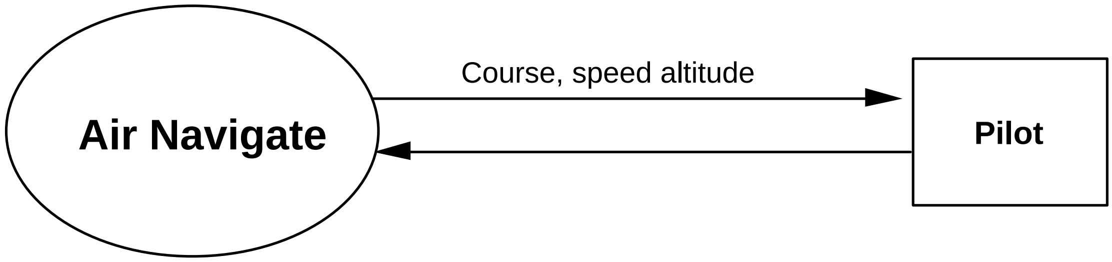


Figure D-12. Data flow diagram for Select Delivery Platform state.



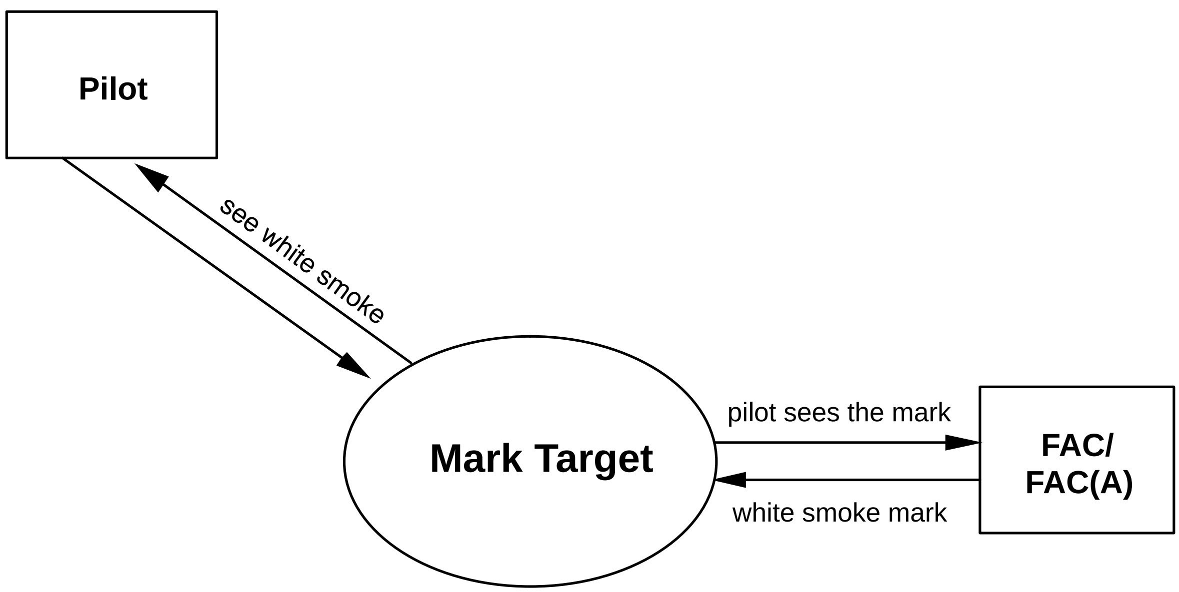
Note: FAC (or FAC(A)) will formulate a “FAC Briefing Card” that includes these (and in the case of Beacon Bombing other) data. JCS publication 12, Vol. II has detailed info on Joint Tactical Air Strike Request.

Figure D-13. Data flow diagram for Brief Pilots state.



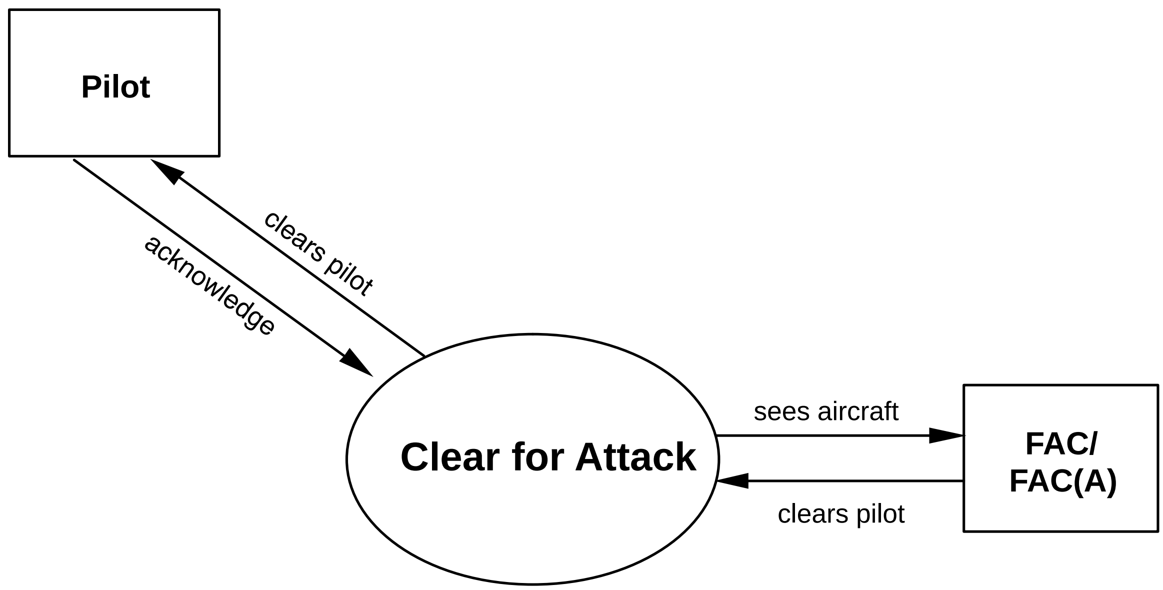
Note: The most basic, but most critical task, a pilot does is fly the aircraft, i.e., “Air Navigate.” If he does it wrong through a lack of training or experience or improperly through a lack of attention, the mission will not succeed.

Figure D-14. Data flow diagram for Air Navigate state.



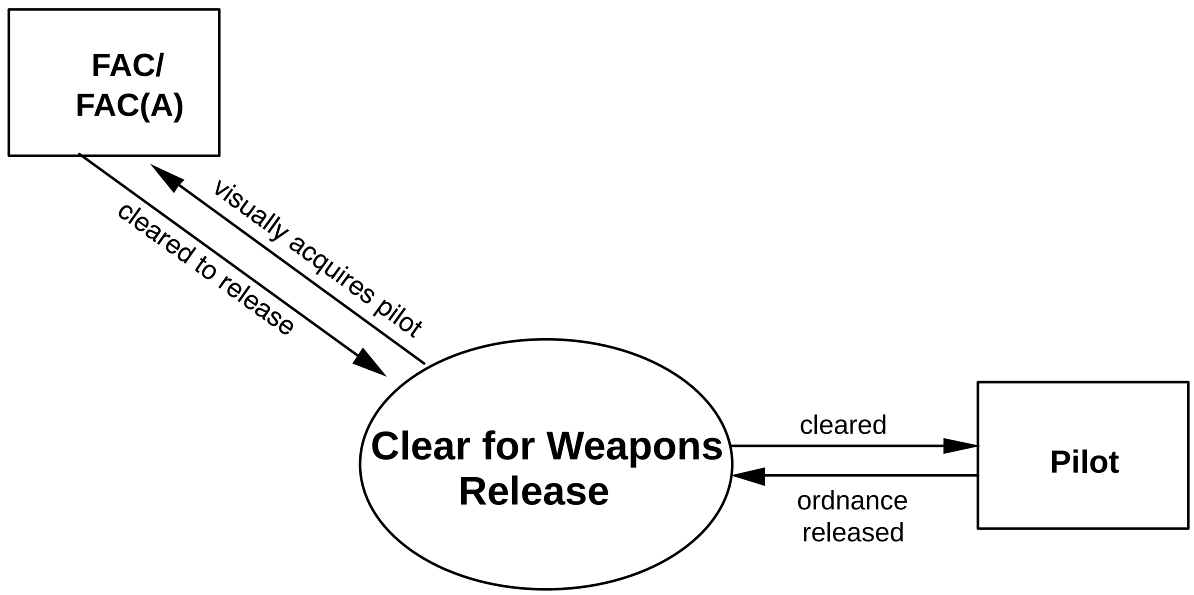
Note: When the pilot is in the immediate vicinity of the target, he may (or more likely may not) see the actual target. At that time, the FAC will mark the target in some manner (white smoke) to make sure the pilot drops his ordnance in the right place.

Figure D-15. Data flow diagram for Mark Target state.



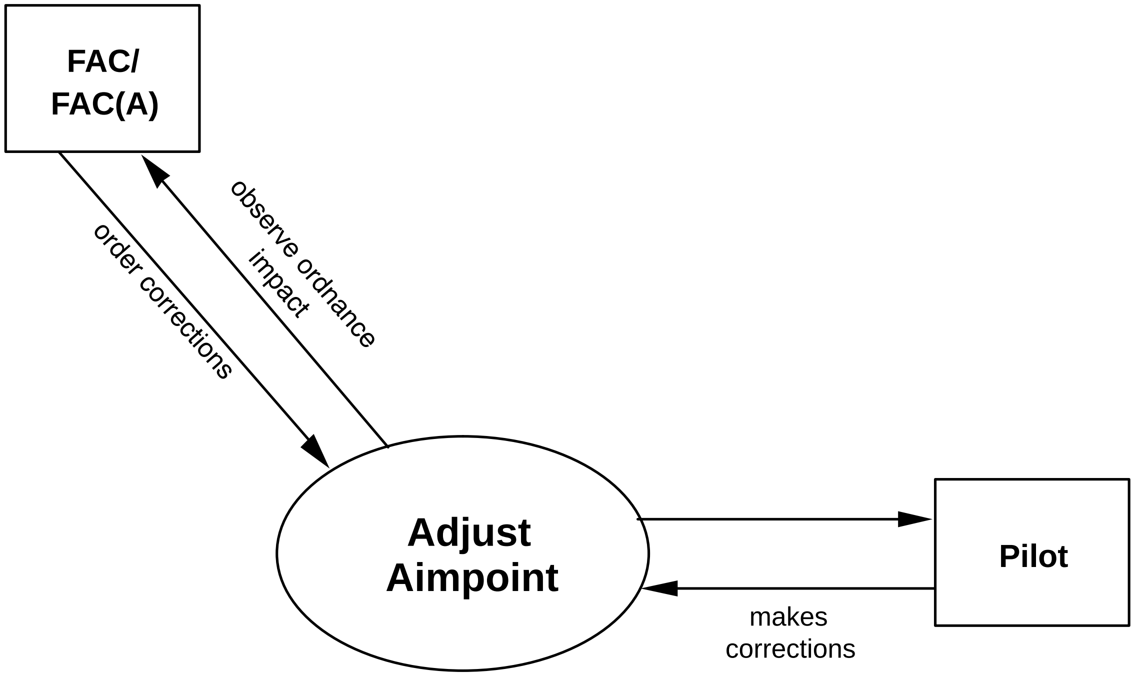
Note: If the pilot sees the mark, acknowledges correction from the mark, and the FAC(A) sees the pilot, he is cleared to make his target run.

Figure D-16. Data flow diagram for Clear for Attack state.



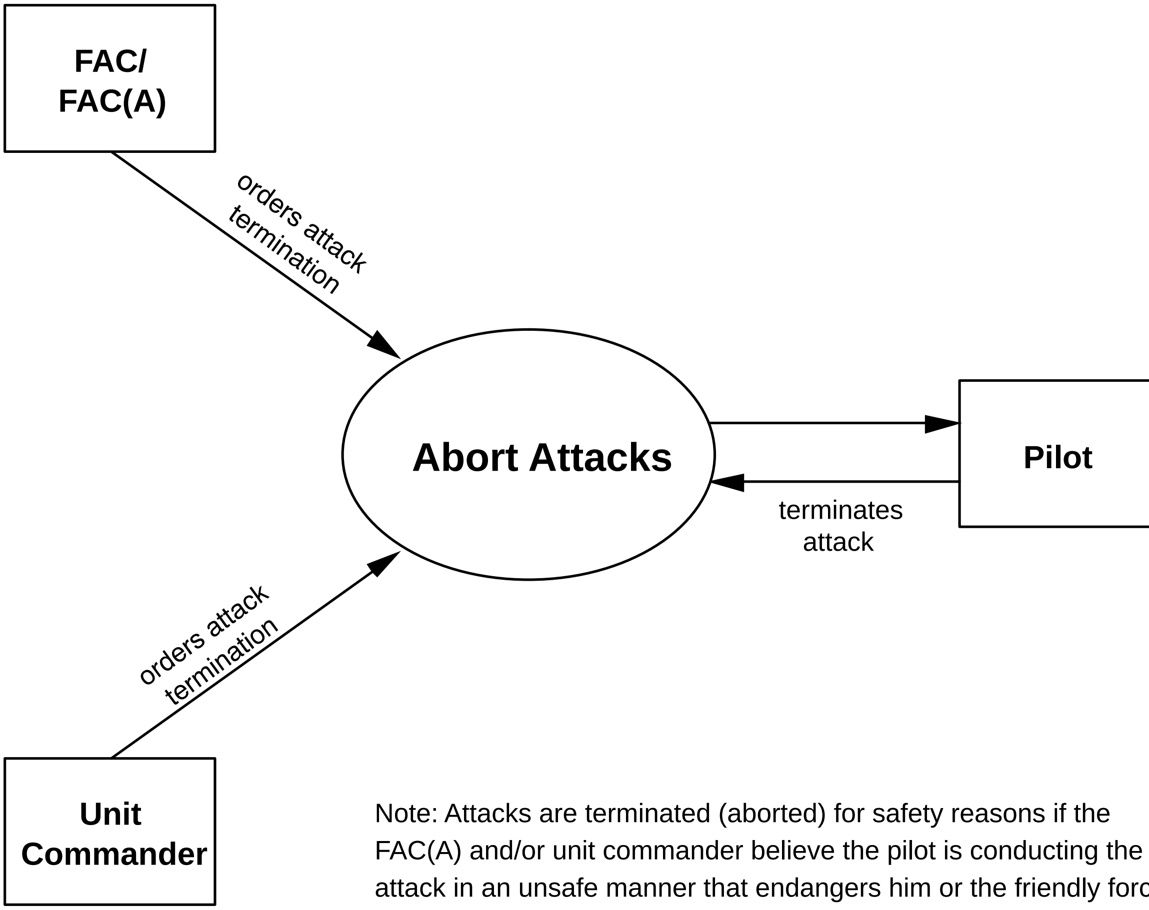
Note: The final control measure, to ensure the pilot has acquired the right target and won't release his ordnance on friendlies, is to visually make sure the pilot is pointing at the target; at that time he is cleared for ordnance release. If he does not receive this clearance, he <u>must</u> <u>not</u> release the ordnance.

Figure D-17. Data flow diagram for Clear for Weapons Release state.



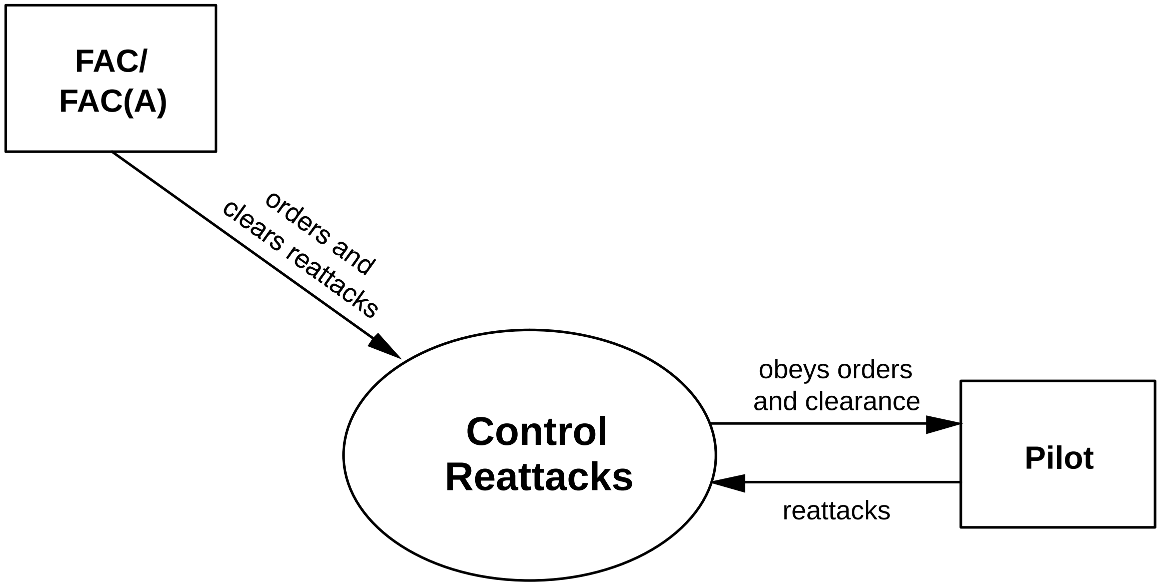
Note: The FAC(A) observes where the ordnance has impacted and tells the pilot to change his aimpoint to directly impact the target. This procedure is repeated on subsequent "runs" until the target is destroyed or the pilot has exhausted his ordnance supply.

Figure D-18. Data flow diagram for FAC Adjust Aimpoint state.



Note: Attacks are terminated (aborted) for safety reasons if the FAC(A) and/or unit commander believe the pilot is conducting the attack in an unsafe manner that endangers him or the friendly forces on the ground.

Figure D-19. Data flow diagram for Abort Attacks state.



Note: Reattacks are performed under positive control and in the same manner as before.

Figure D-20. Data flow diagram for Control Reattacks state.

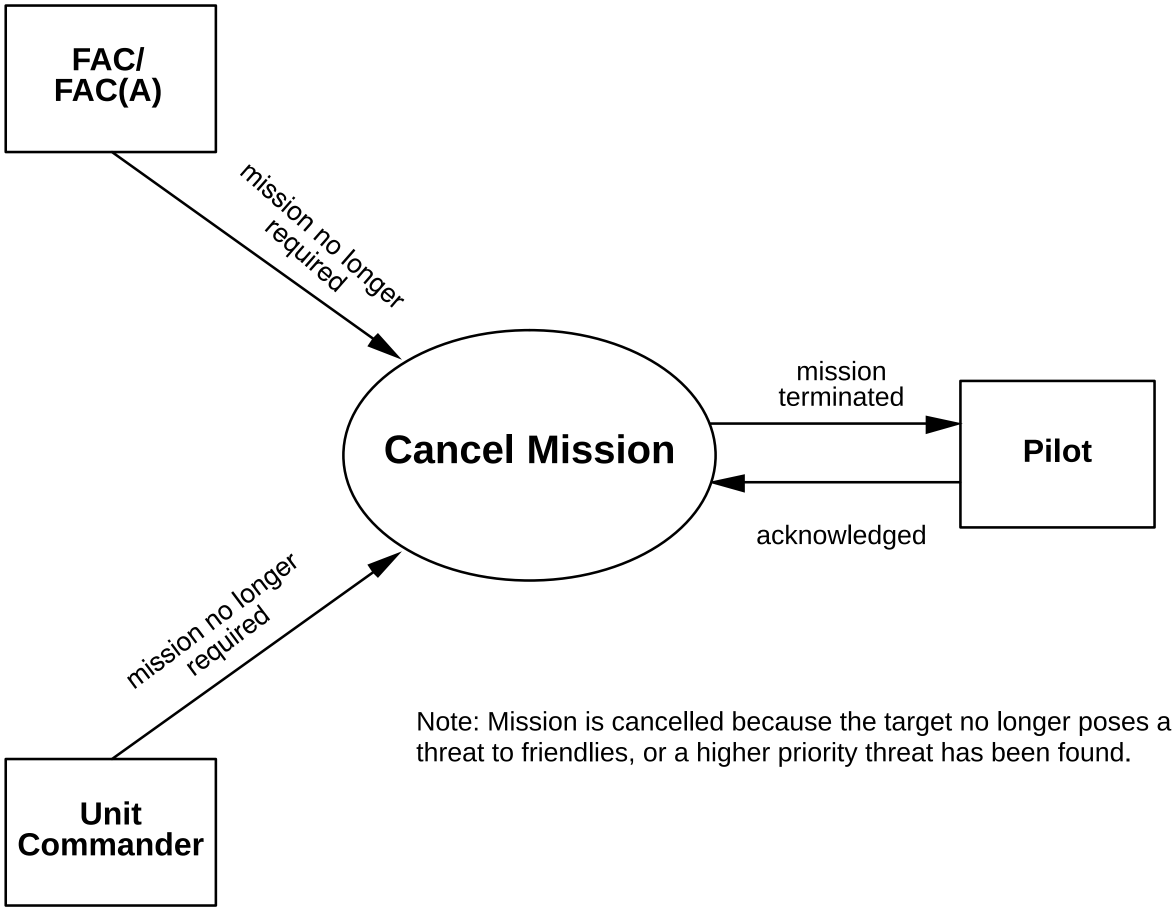


Figure D-21. Data flow diagram for Cancel Mission state.

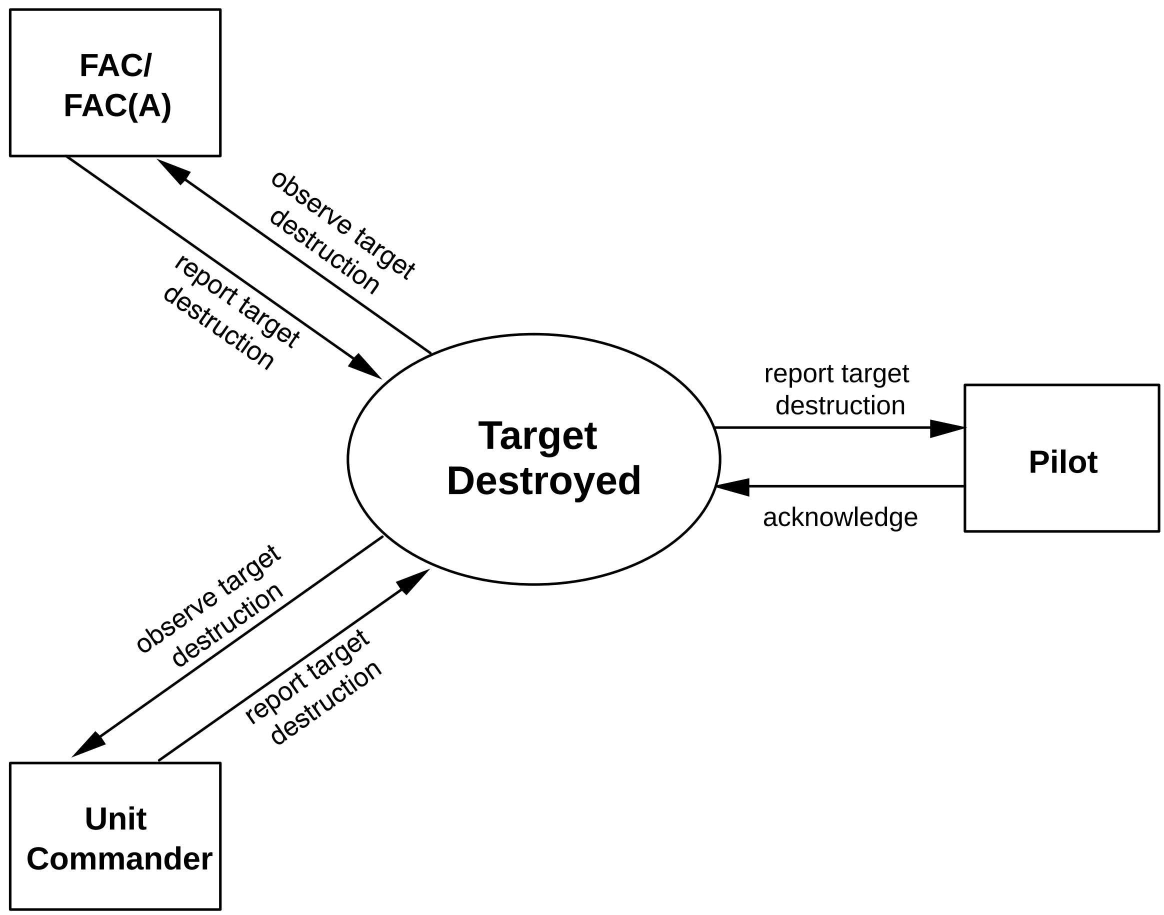


Figure D-22. Data flow diagram for Target Destroyed state.

Organization

Military

Forward Air Controller (FAC)

C^2

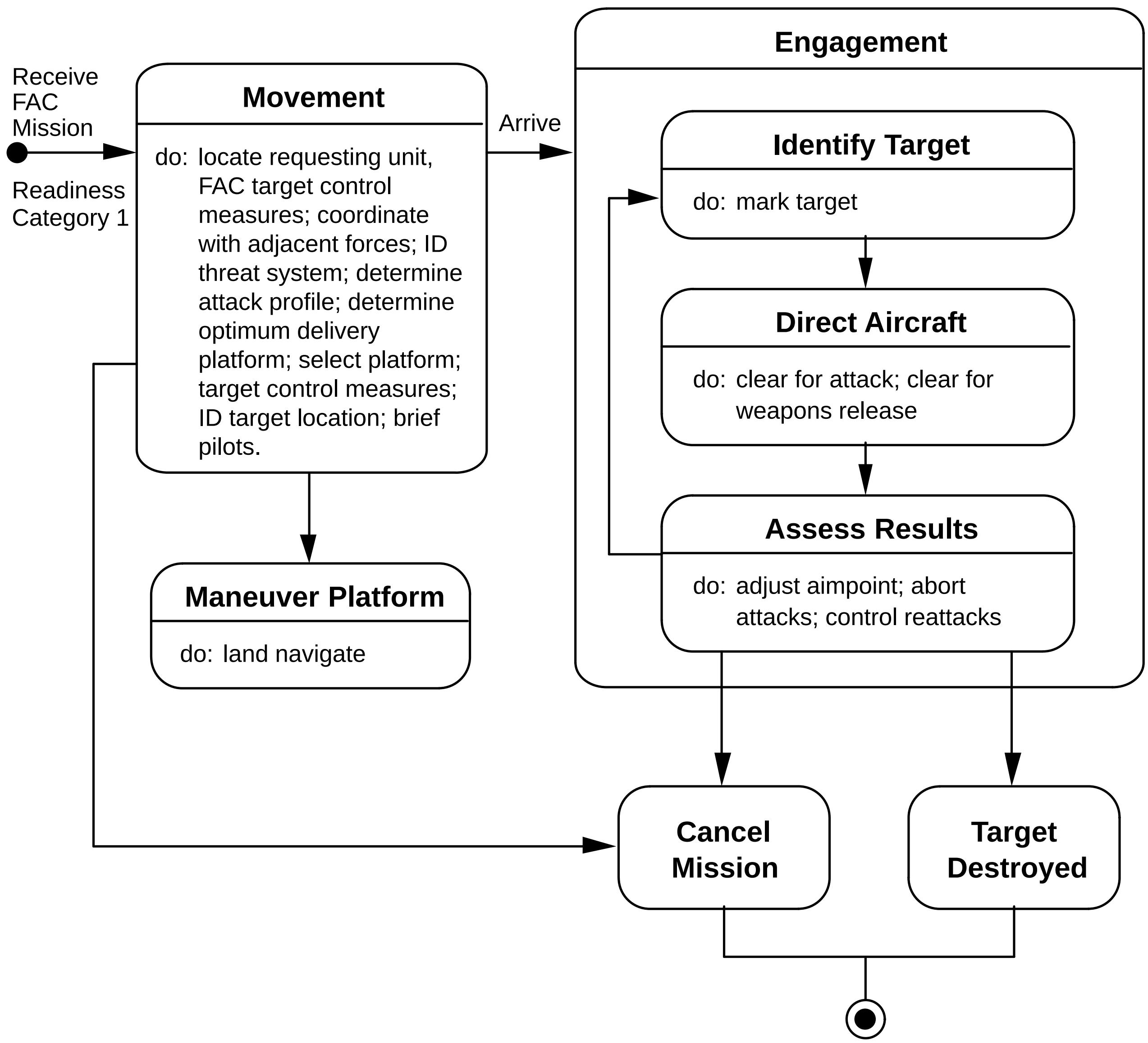
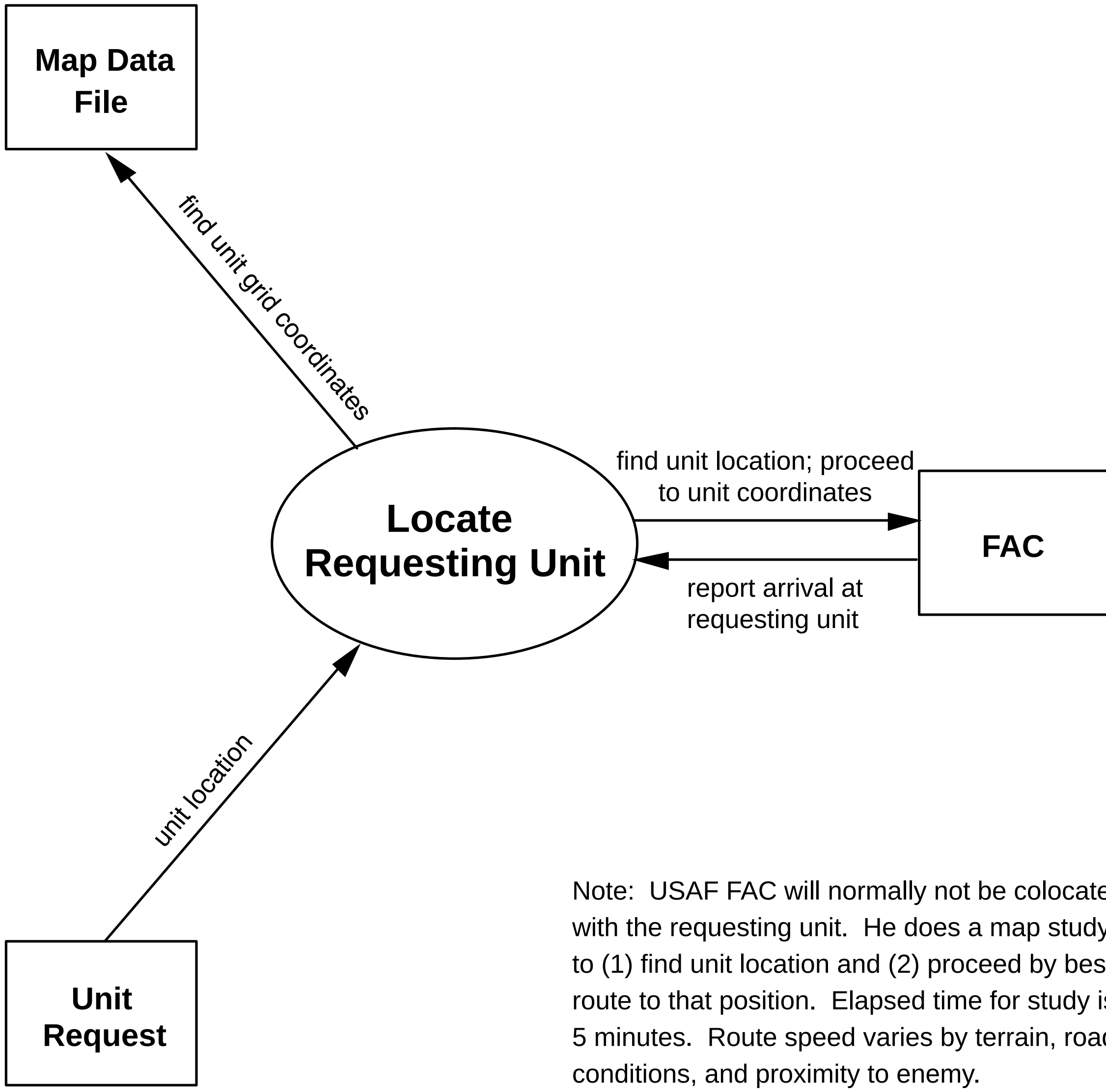


Figure D-23. State diagram for the mission of Forward Air Controller (FAC).



Note: USAF FAC will normally not be colocated with the requesting unit. He does a map study to (1) find unit location and (2) proceed by best route to that position. Elapsed time for study is 5 minutes. Route speed varies by terrain, road conditions, and proximity to enemy.

Figure D-24. Data flow diagram for Locate Requesting Unit state.

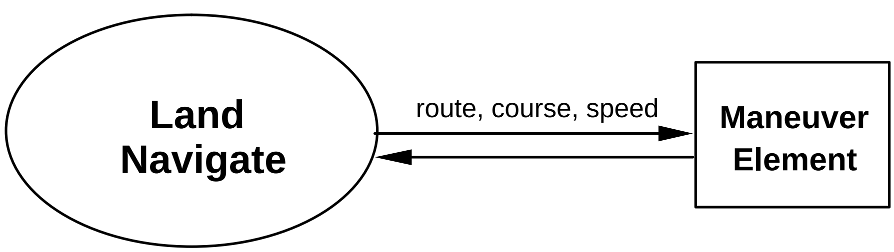


Figure D-25. Data flow diagram for Land Navigate state.

Organization

Military

Pilot

C^2

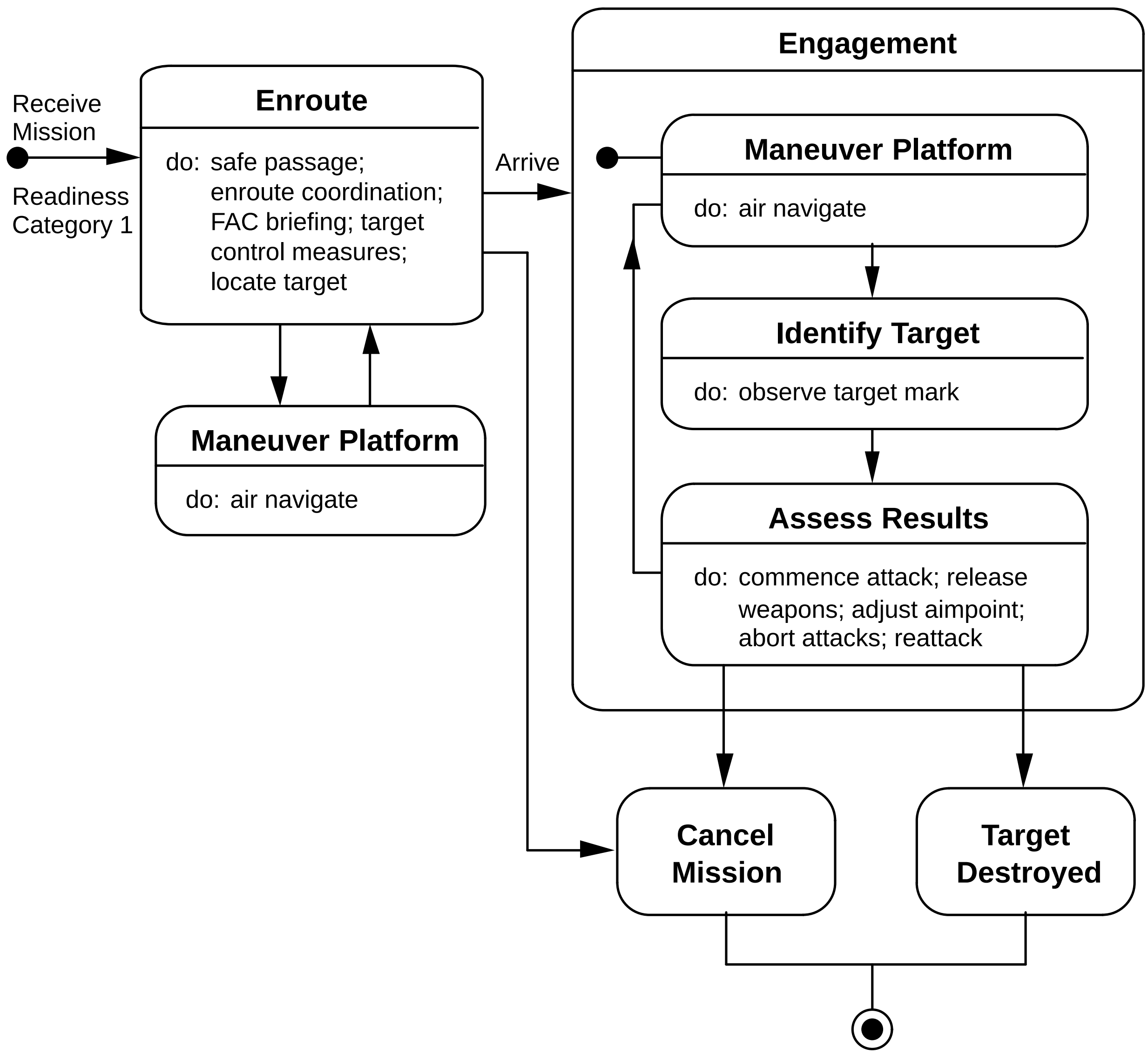
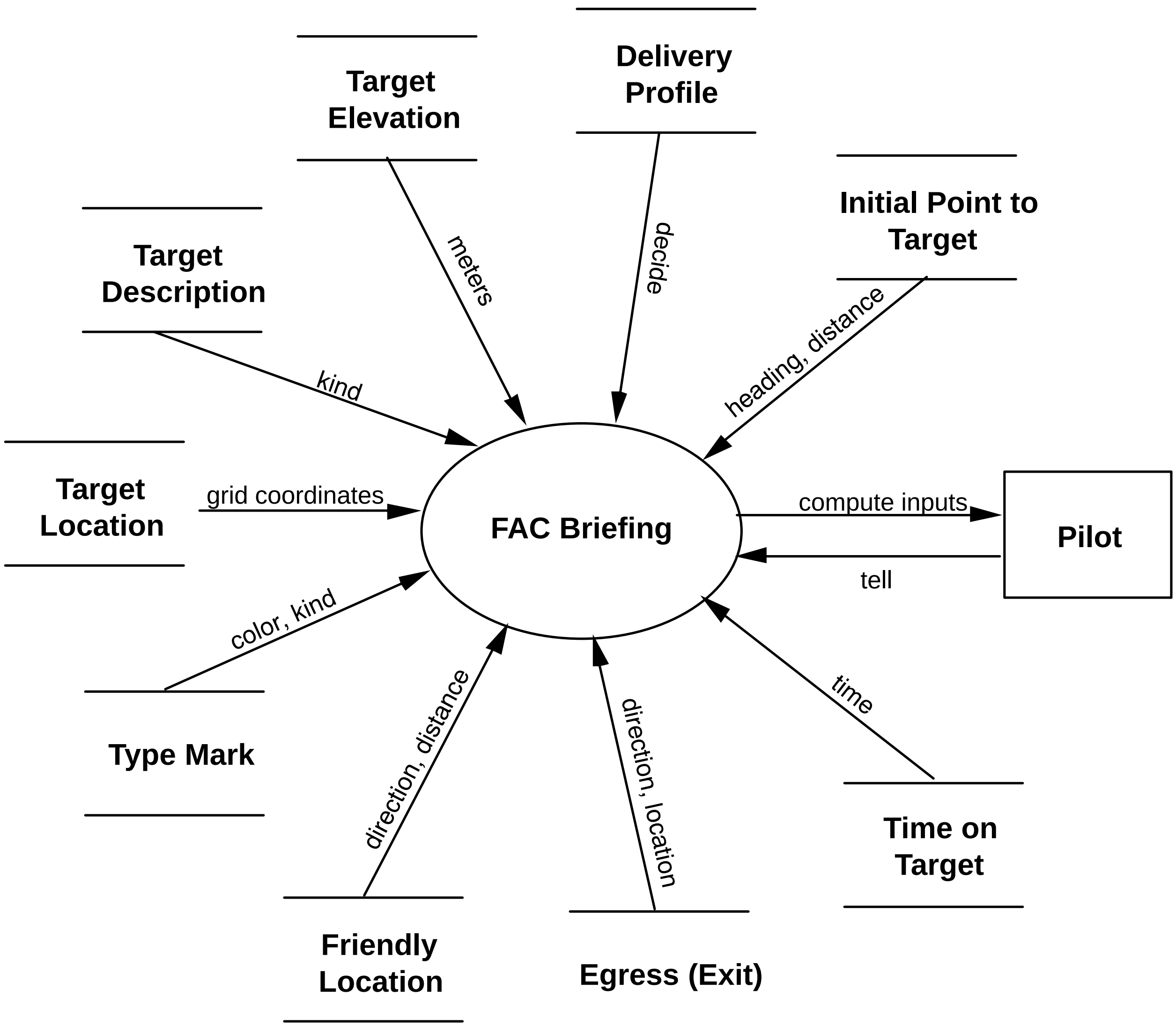
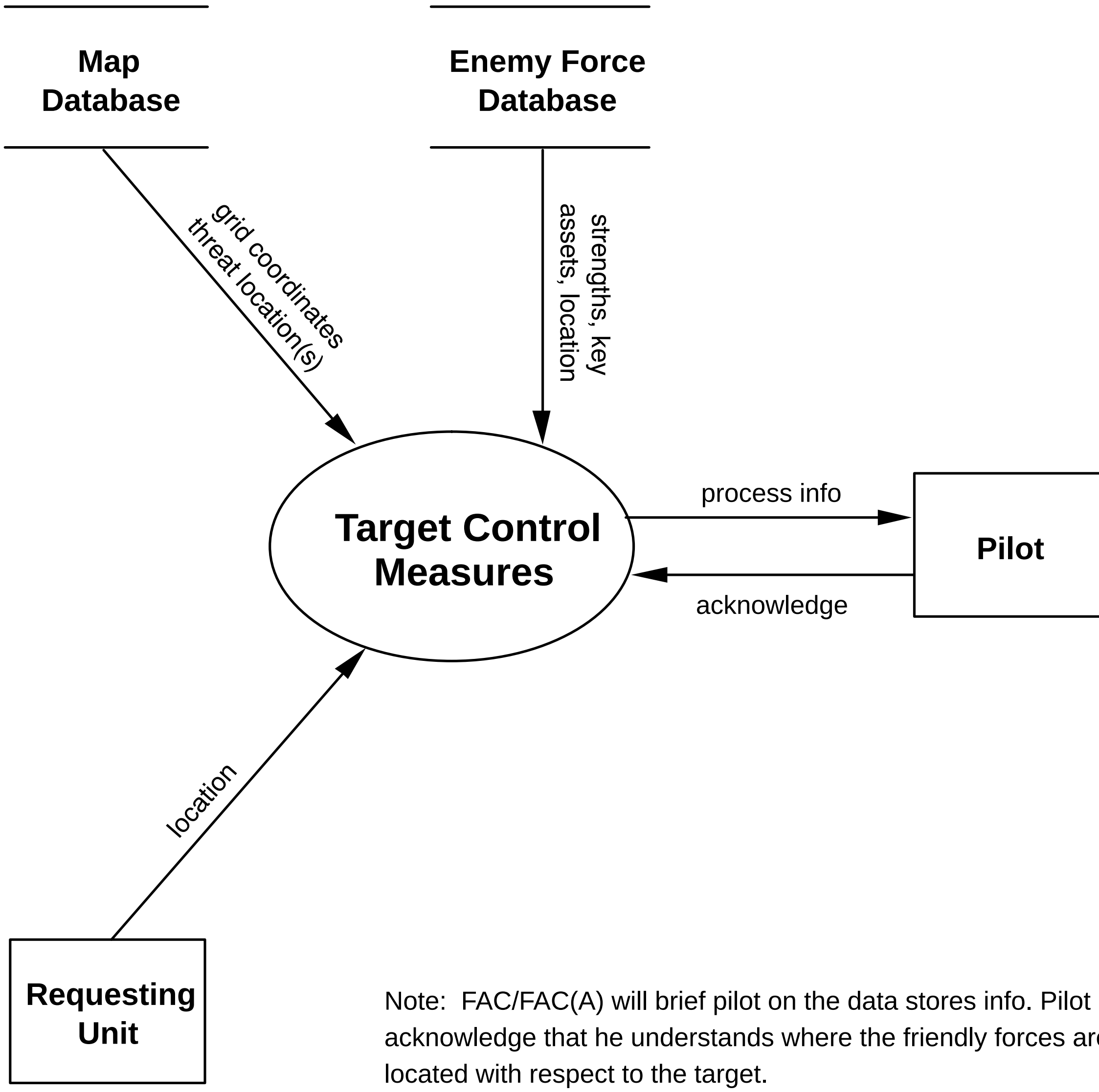


Figure D-26. State diagram for the mission of Close Air Support (CAS).



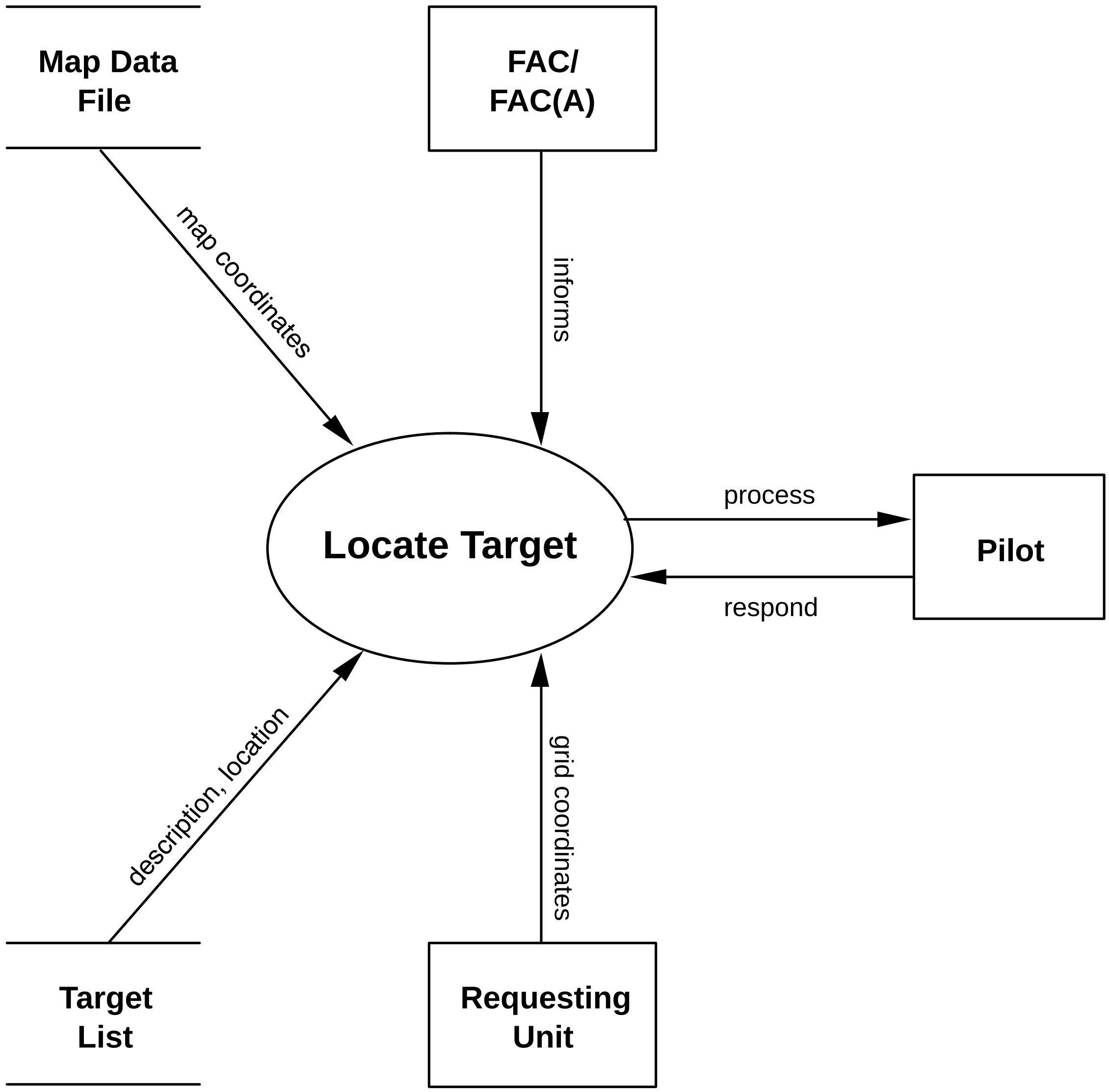
Note: FAC or FAC(A) provides details of how the mission will be conducted. Pilot repeats all instructions and must not deviate unless approved by FAC/FAC(A).

Figure D-27. Data flow diagram for close air support FAC Briefing state.



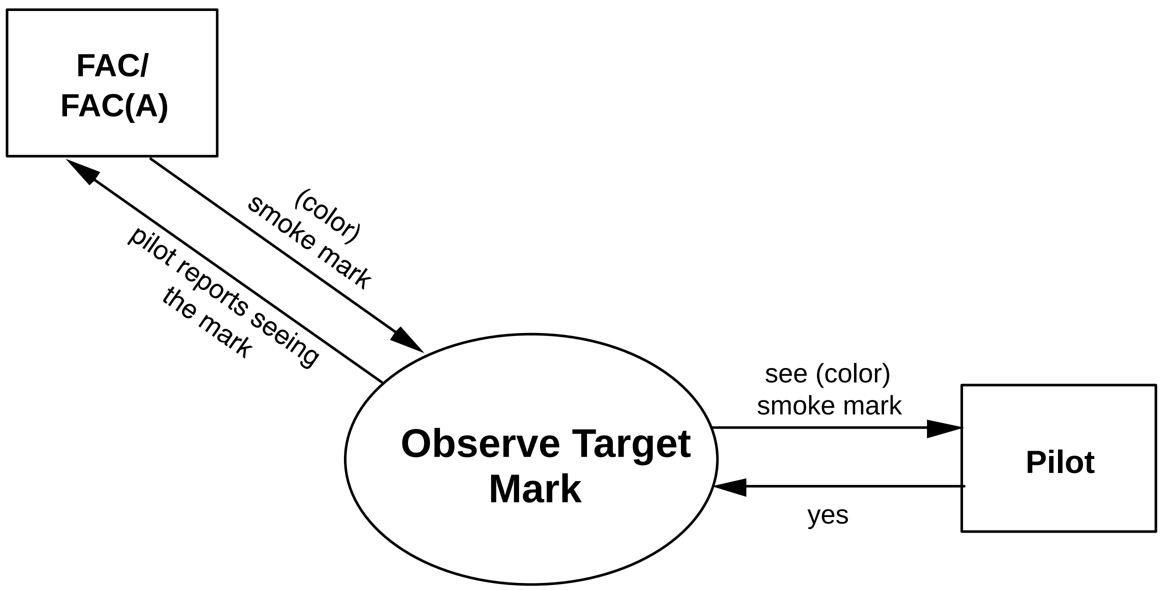
Note: FAC/FAC(A) will brief pilot on the data stores info. Pilot must acknowledge that he understands where the friendly forces are located with respect to the target.

Figure D-28. Data flow diagram for close air support Target Control Measures state.



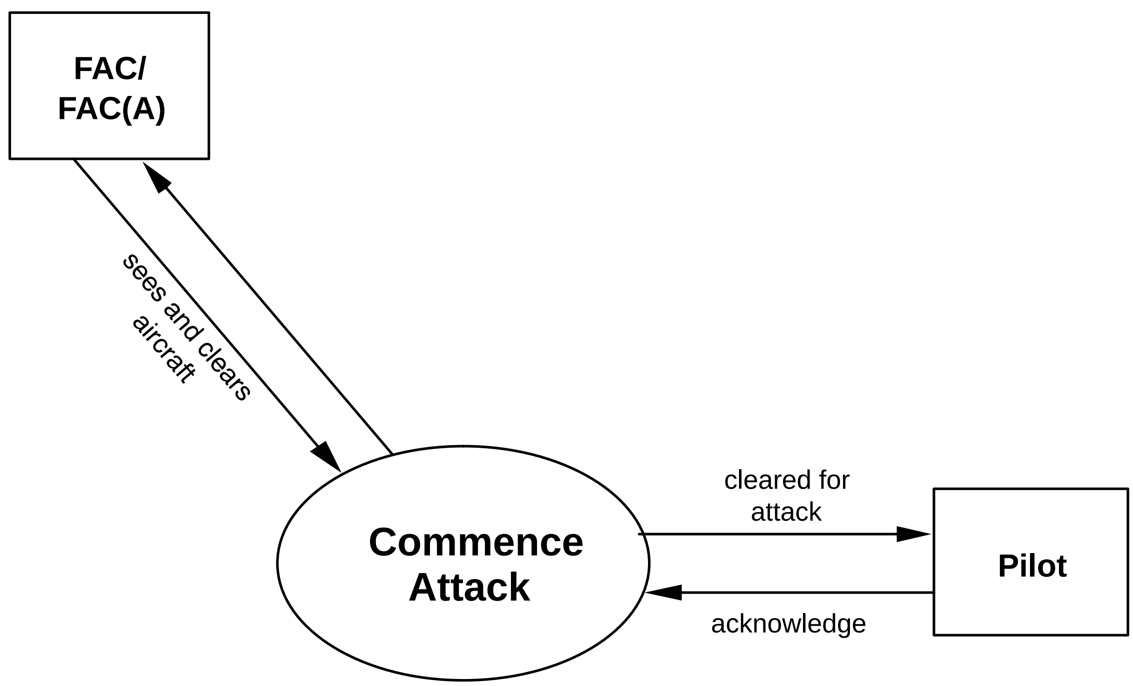
Note: Aggregate of the data stores and, in particular, FAC/FAC(A) directs pilot to the target or target area.

Figure D-29. Data flow diagram for close air support Locate Target state.



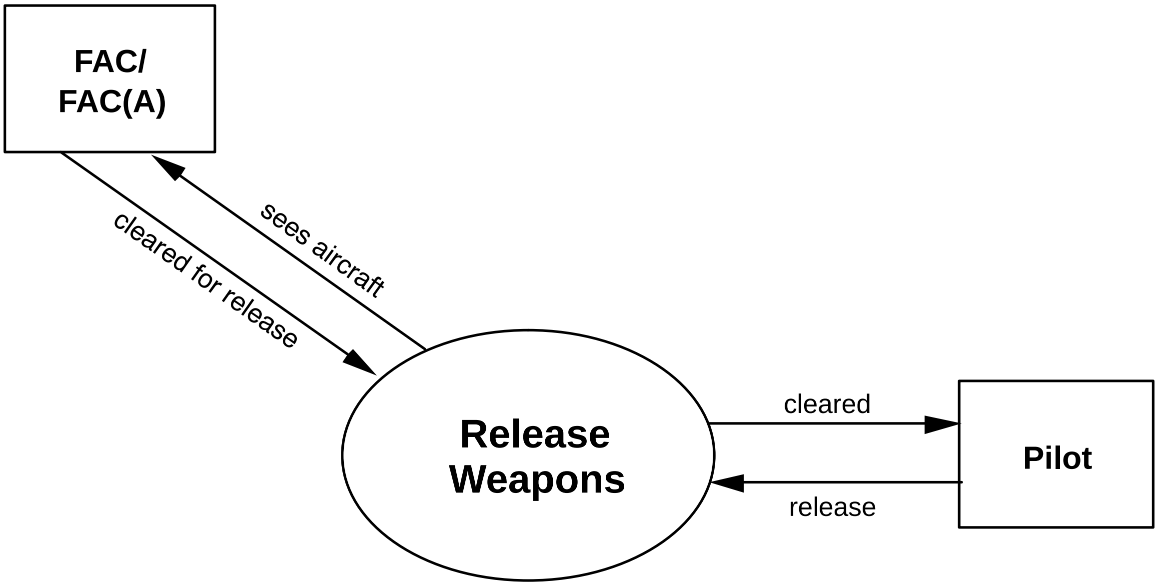
Note: FAC or FAC(A) marks the target and provides correction information. Pilot sees the mark and acknowledges where to correct from the mark.

Figure D-30. Data flow diagram for close air support Observe Target Mark state.



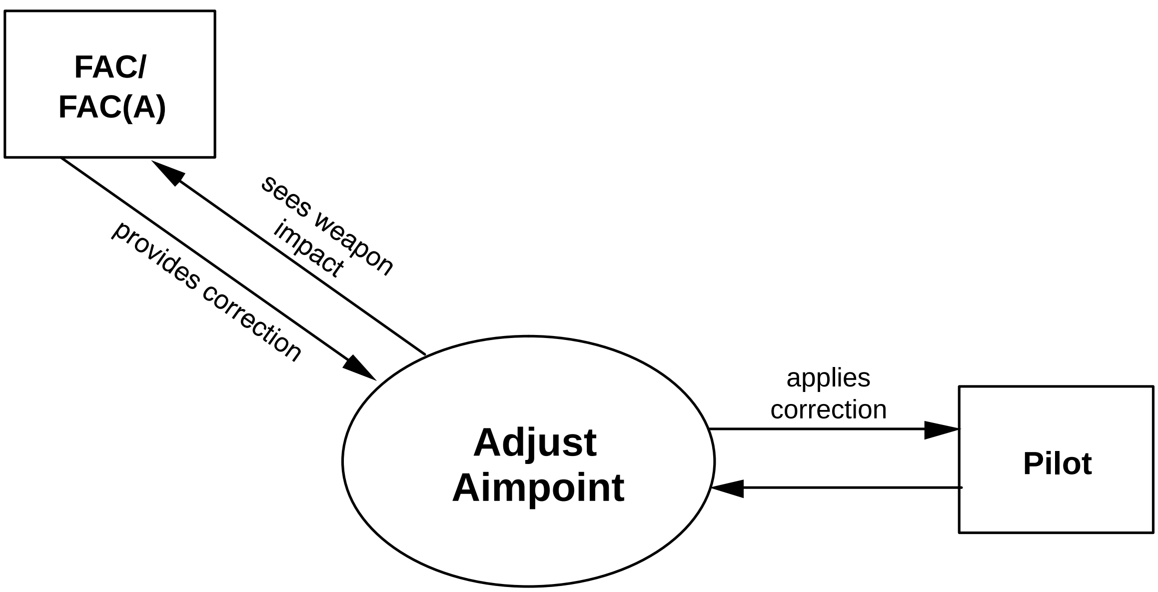
Note: FAC or FAC(A) observes the aircraft has apparently acquired the target and clears the pilot to commence the attack.

Figure D-31. Data flow diagram for close air support Commence Attack state.



Note: When the pilot is established in the flight path and pointed at the target, he is cleared to release weapons. Pilot releases weapons if he is sure he has target and the flight path is an accceptable one.

Figure D-32. Data flow diagram for close air support Release Weapons state.



Note: FAC or FAC(A) provides correction information from target mark. Pilot applies the correction information, adjusts the flight path, and acknowledges FAC/FAC(A) correction information from the mark.

Figure D-33. Data flow diagram for close air support Adjust Aimpoint state.

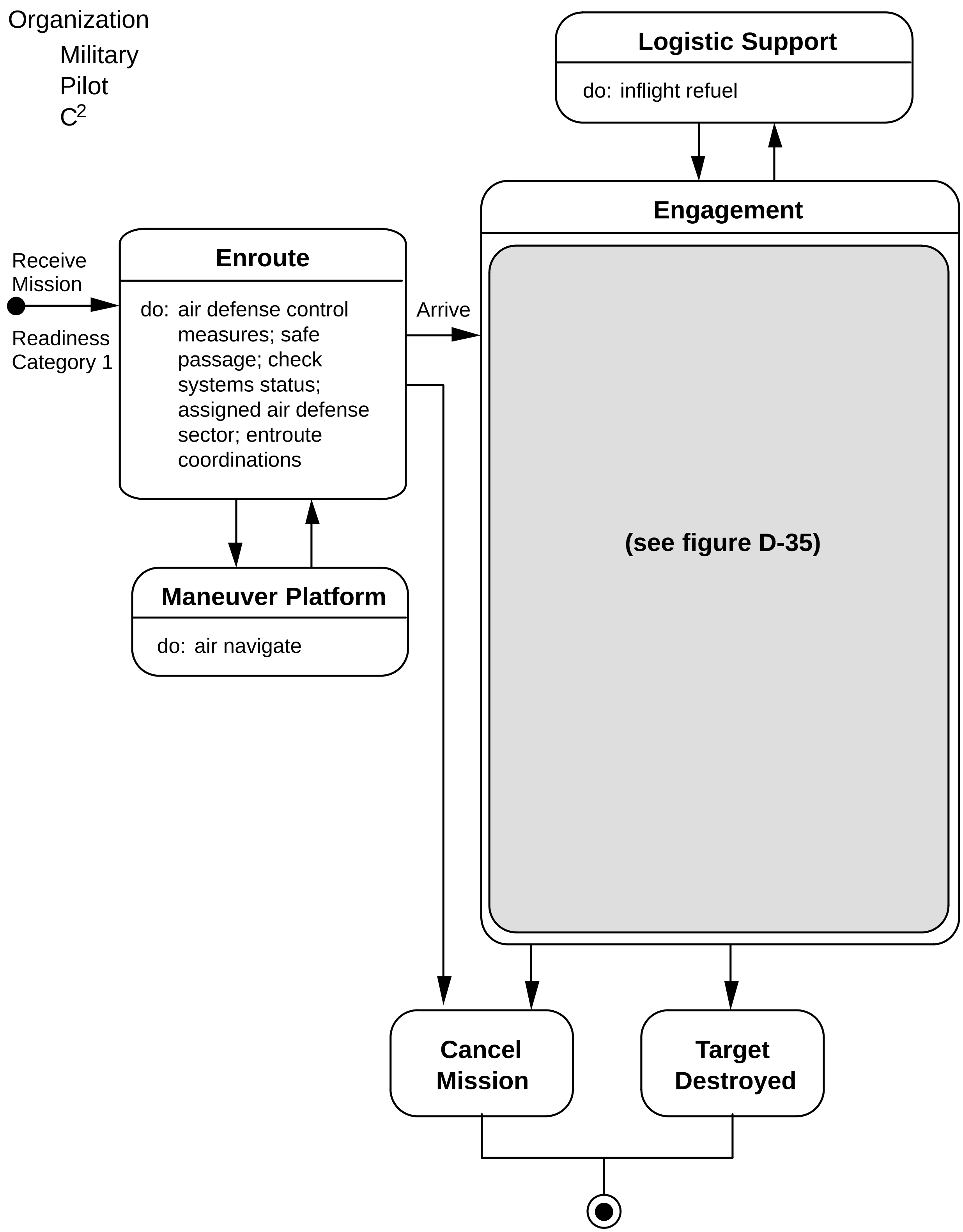


Figure D-34. State diagram for the mission of offensive counterair operations.

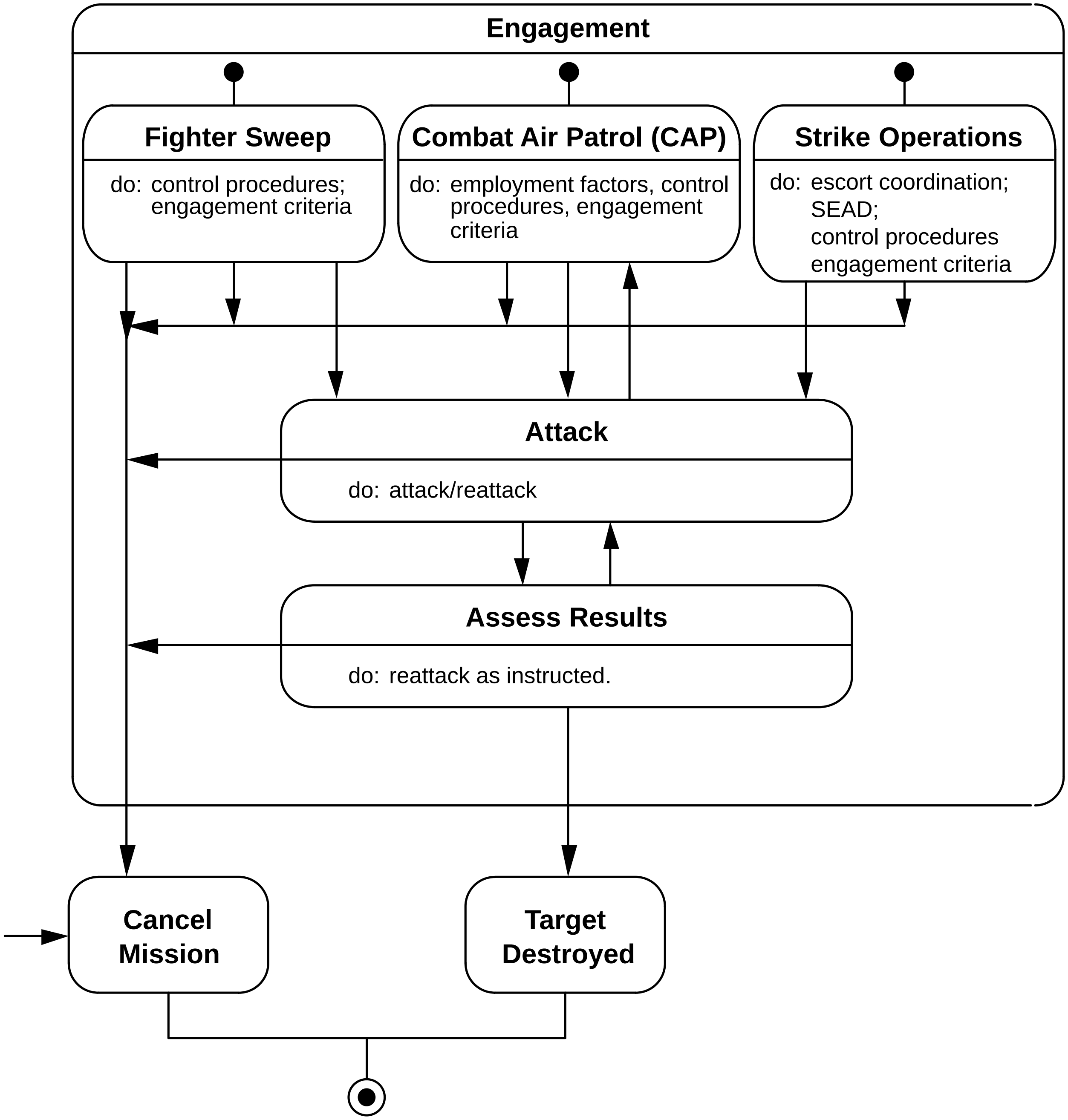
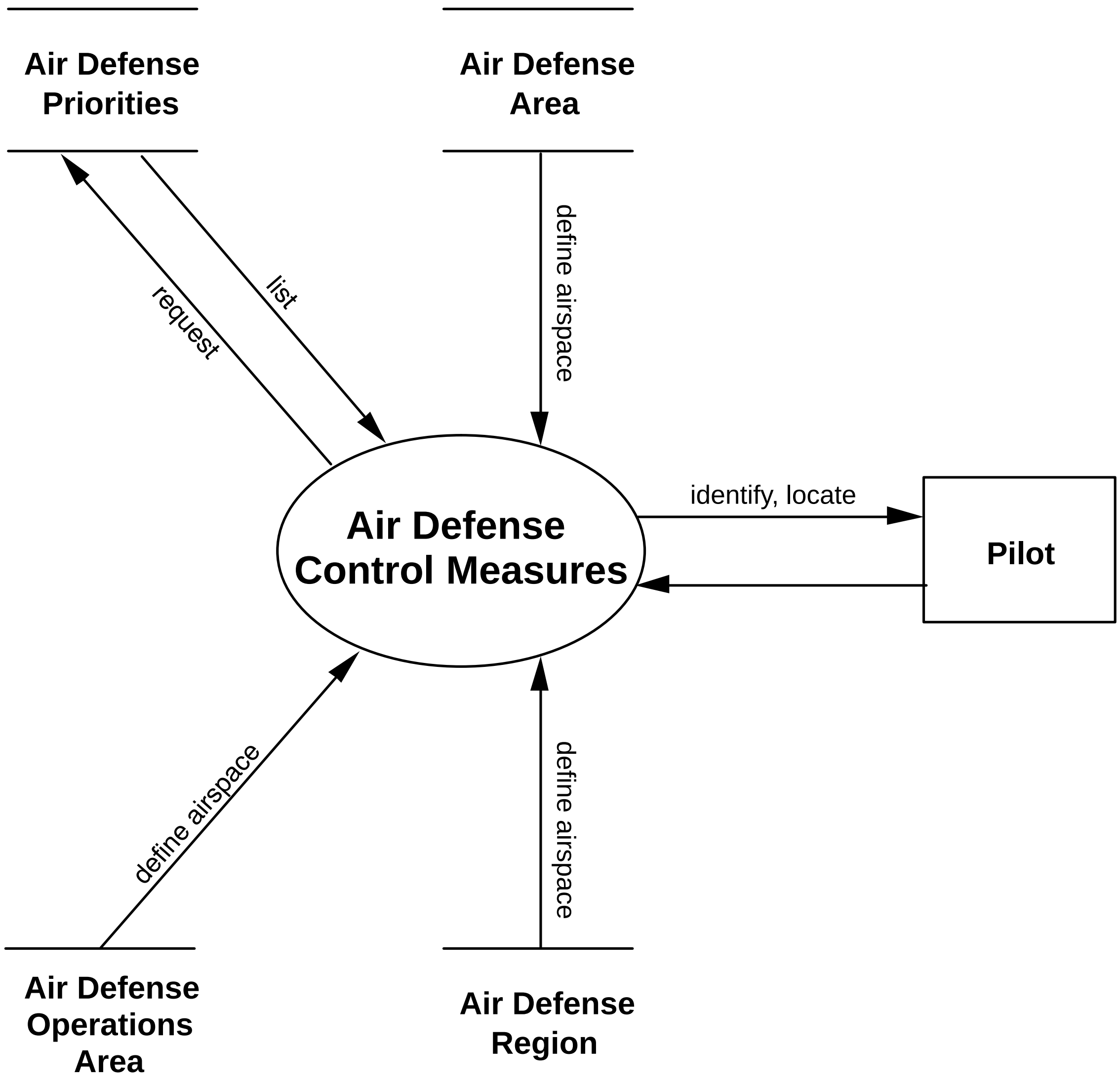
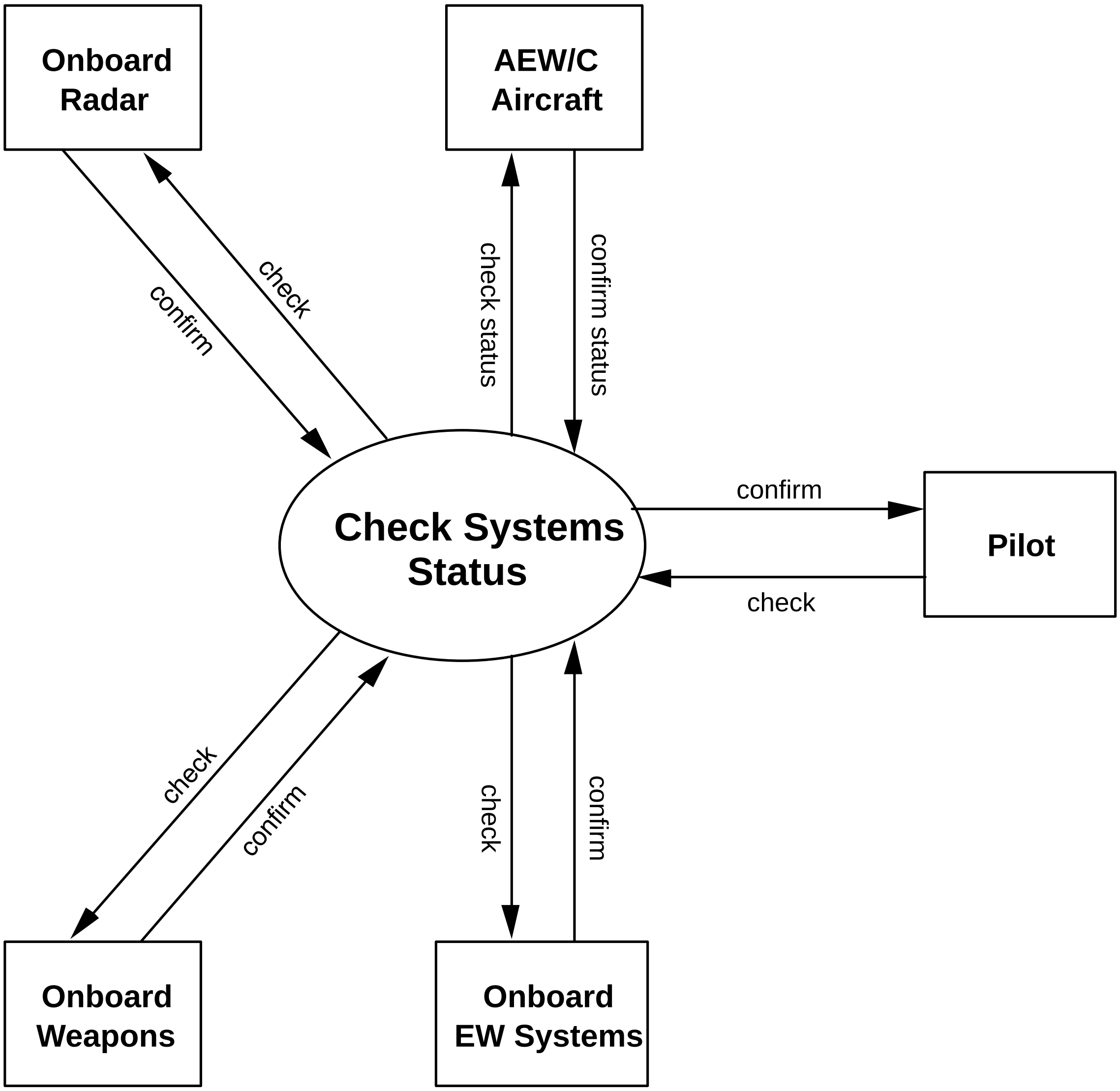


Figure D-35. State diagram for the engagement of offensive counterair operations.



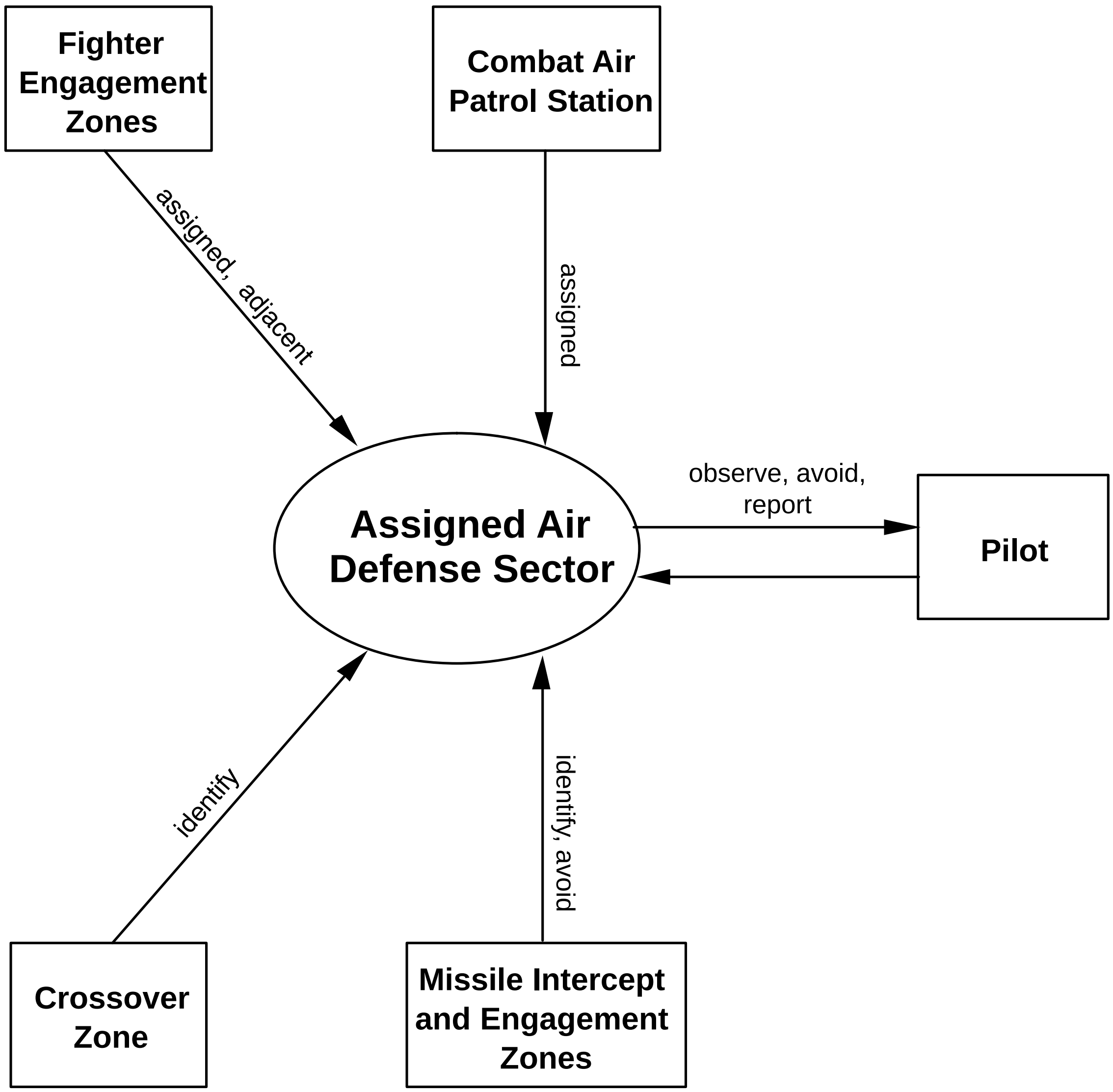
Note: The pilot must know and update his knowledge of the most important air defense priorities (i.e., which enemy assets are the most critical, which are the most vulnerable, recovery time from inflicted damage, and those enemy assets most vulnerable). He must also know and recognize the Air Defense Operations Area and the specific Air Defense Area and Region he is scheduled to operate within.

Figure D-36. Data flow diagram for offensive counterair operations Air Defense Control Measures state.



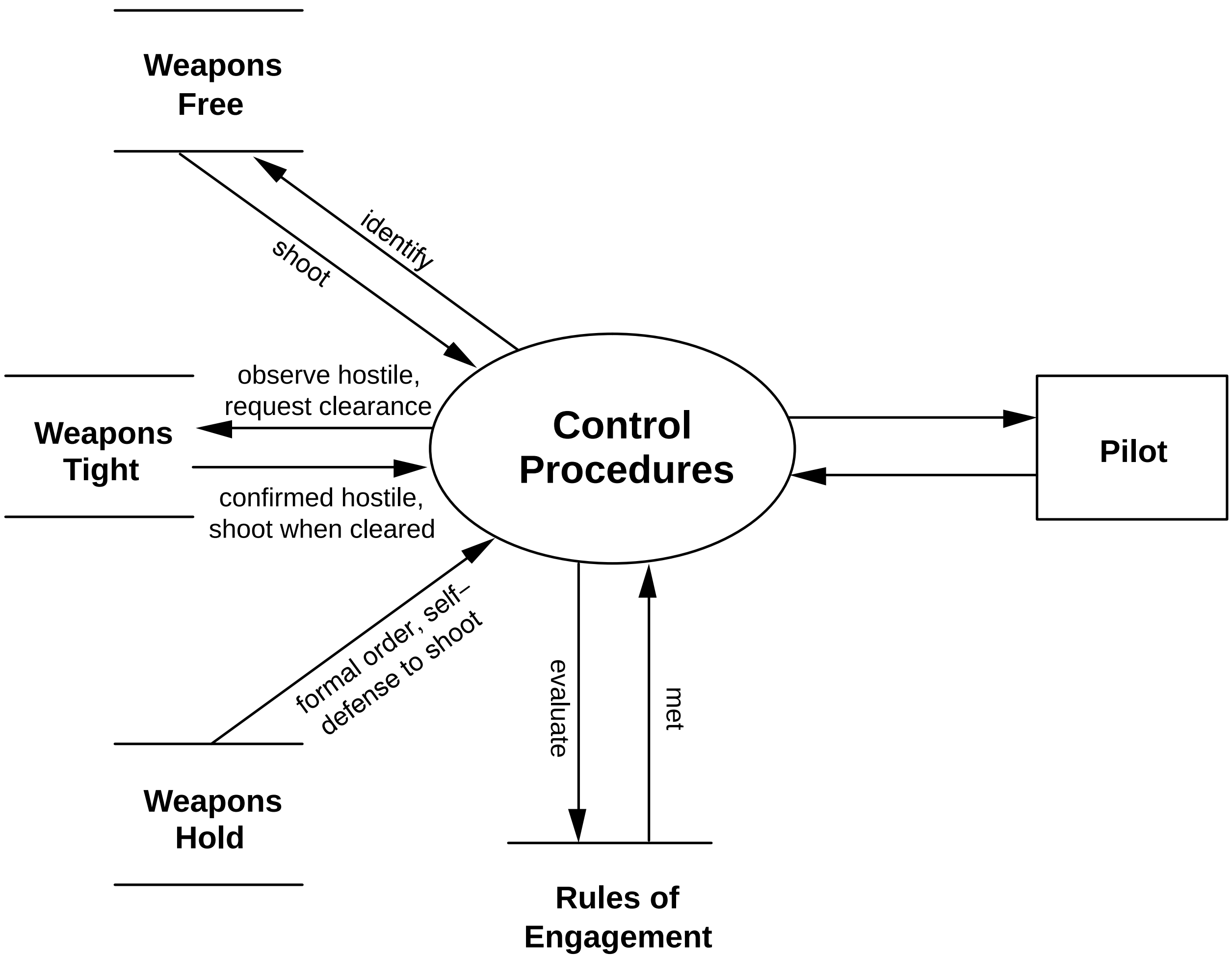
Note: Prior to proceeding with the mission the pilot must confirm that the described systems required for the mission are operating properly (i.e., if AEW/C – Airborne Early Warning and Control aircraft (E–2C/E–3C) are required for the mission they must be operating).

Figure D-37. Data flow diagram for offensive counterair operations Check Weapons Status.



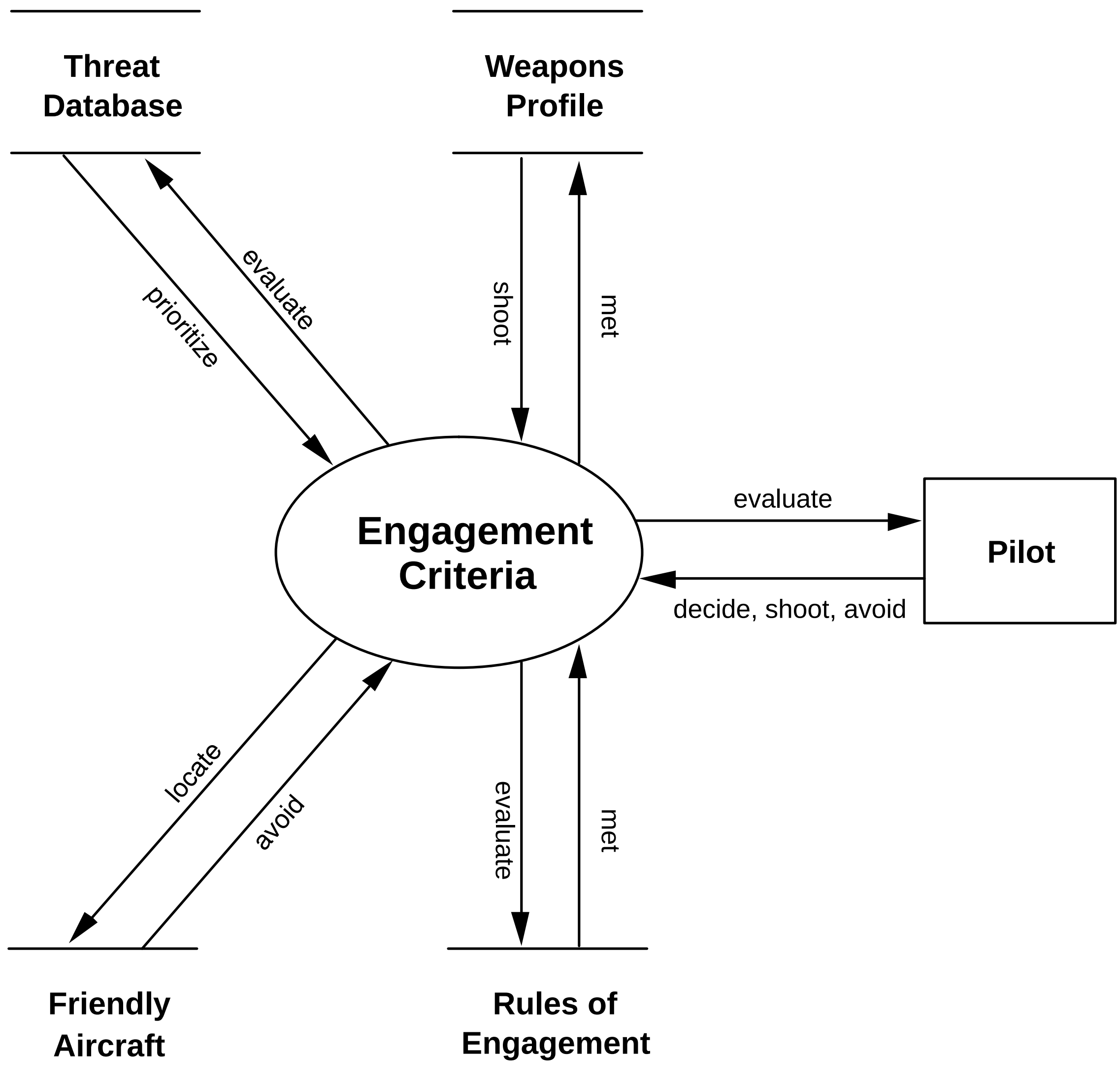
Note: Within a geographically (normally visually identifiable) Air Defense Sector are zones that must be recognized, boundaries that require coordination measures to cross, and missile zones that must be avoided unless executing return to force/exit procedures.

Figure D-38. Data flow diagram for offensive counterair operations Assigned Air Defense Sector state.



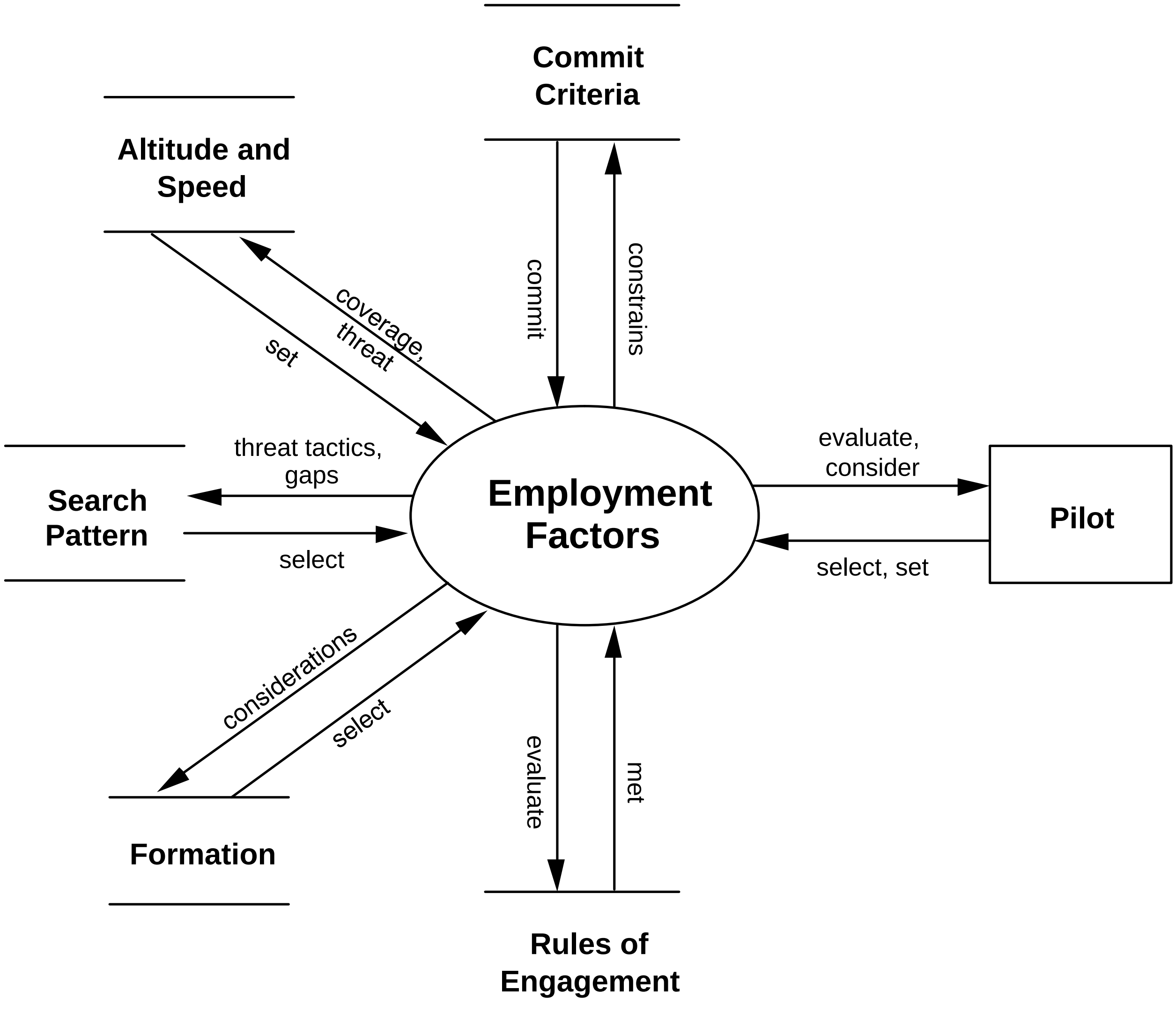
Note: Under “weapons free” criteria, it is assumed anything found on radar or visually is an enemy. The pilot is clear to engage. Under “weapons tight” criteria, engagement is permitted only when cleared or when the ROE has been met.

Figure D-39. Data flow diagram for offensive counterair (fighter sweep) Control Procedures state.



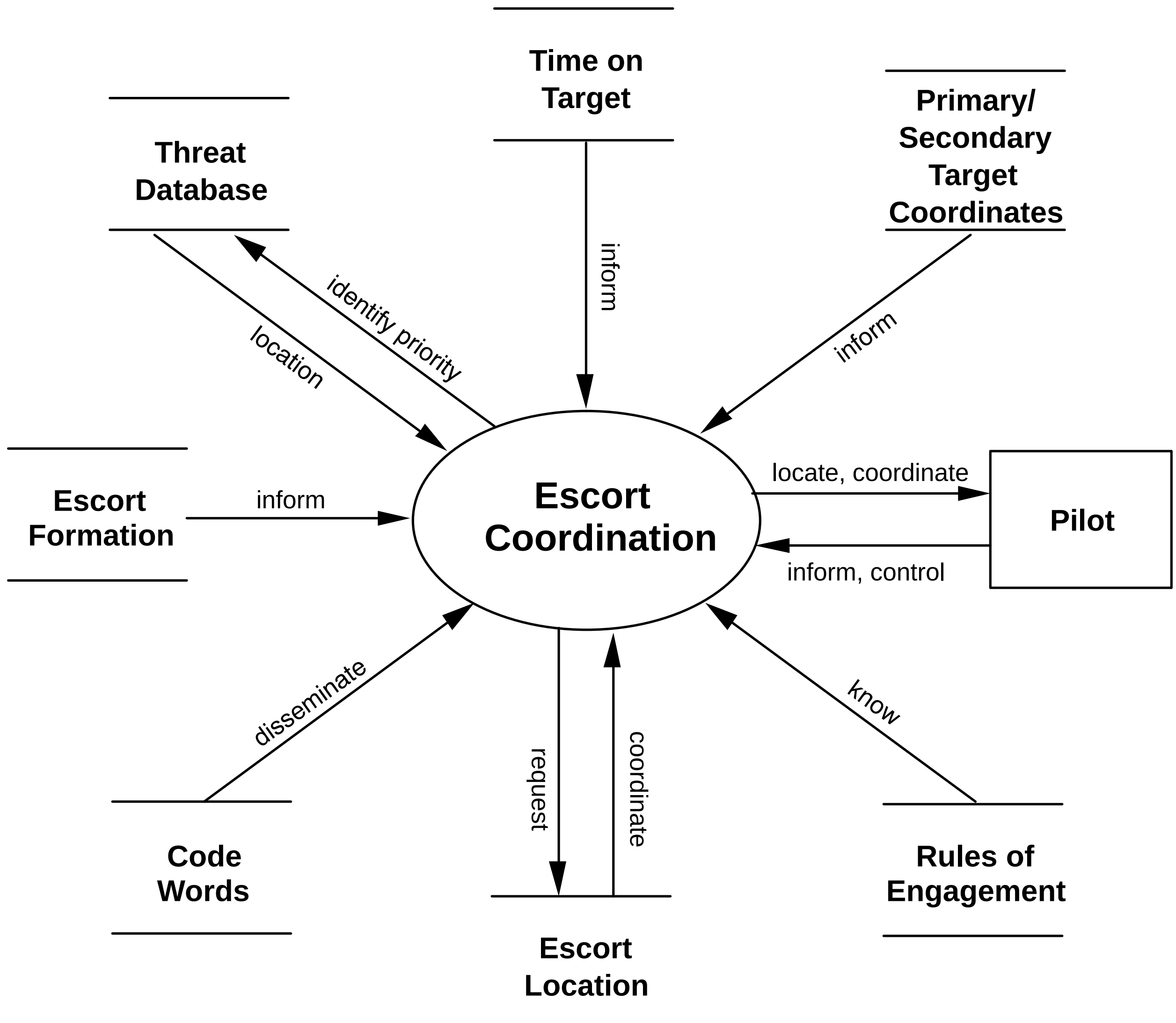
Note: These criteria ensure that the most serious threat will be engaged first, i.e., MIG-31 before MIG-17. ROE criteria must still be met, friendly forces avoided and, critically, the threat aircraft must be within the engagement envelope for the weapon selected.

Figure D-40. Data flow diagram for offensive counterair (fighter sweep) Engagement Criteria state.



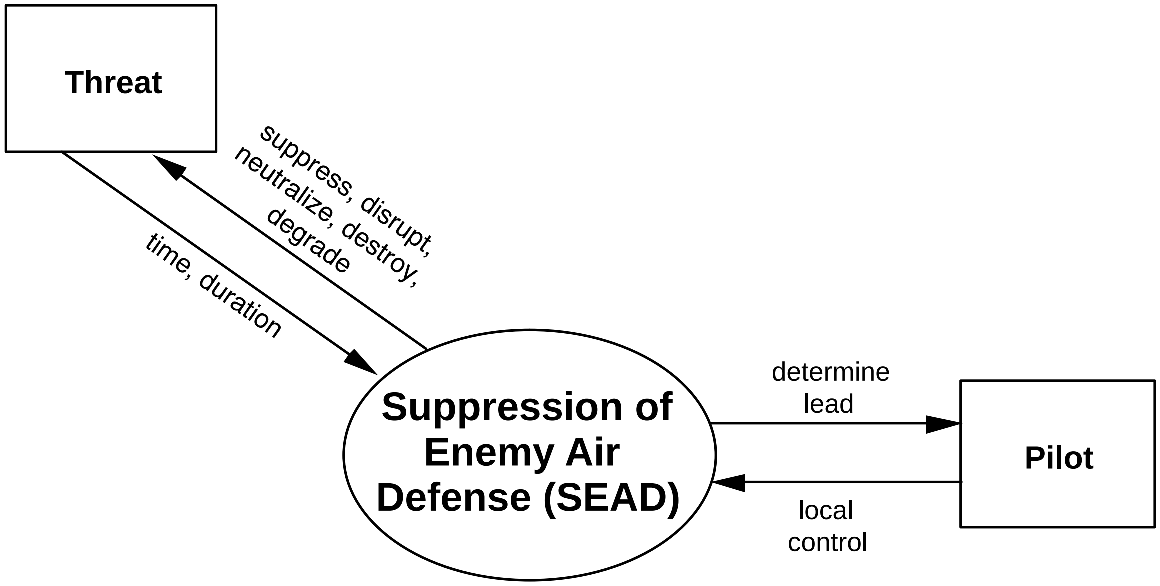
Note: Altitudes are chosen to cover radar gaps; speed depends on enemy threat and time on station requirements. Search patterns cover radar gaps and threat tactics. Formations come from classified tactical manuals. ROE should allow pilots to use offensive tactics. Commit criteria means how and under what conditions attacks are initiated.

Figure D-41. Data flow diagram for offensive counterair (CAP) Employment Factors state.



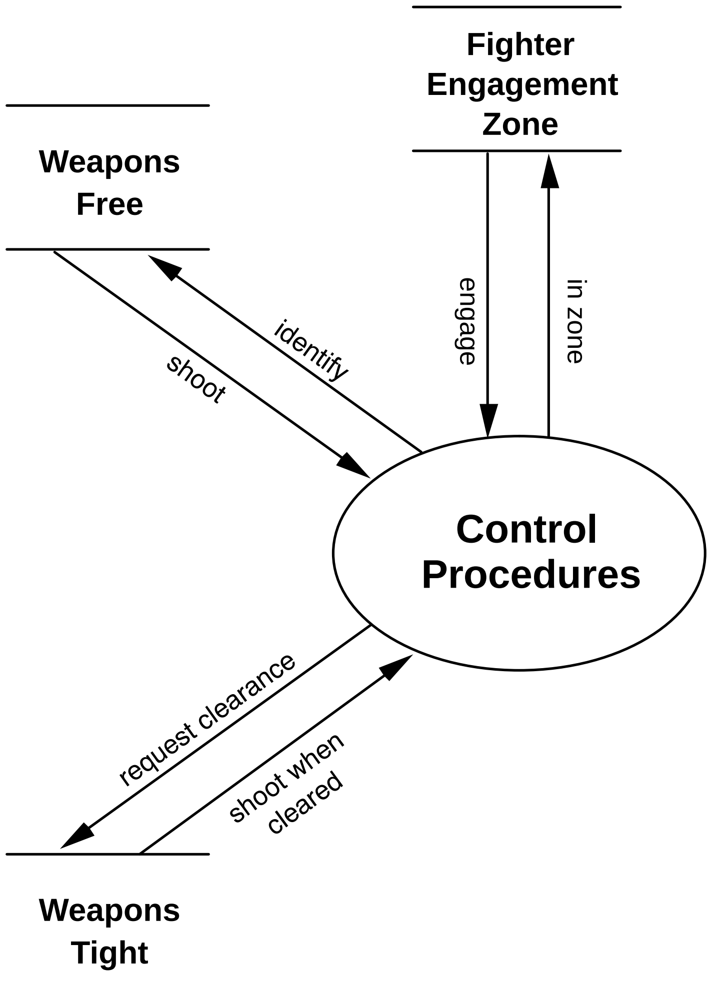
Note: Identify, prioritize, and locate enemy threats. Determine where escort aircraft will be in relation to attack package and what tactical formation they will fly. Ensure all know ROE. Specify time on target for primary/secondary targets. Ensure all know code words for each primary evolution (TOT change, target change, threat attack, etc.).

Figure D-42. Data flow diagram for offensive counterair (strike operations) Escort Coordination stage.



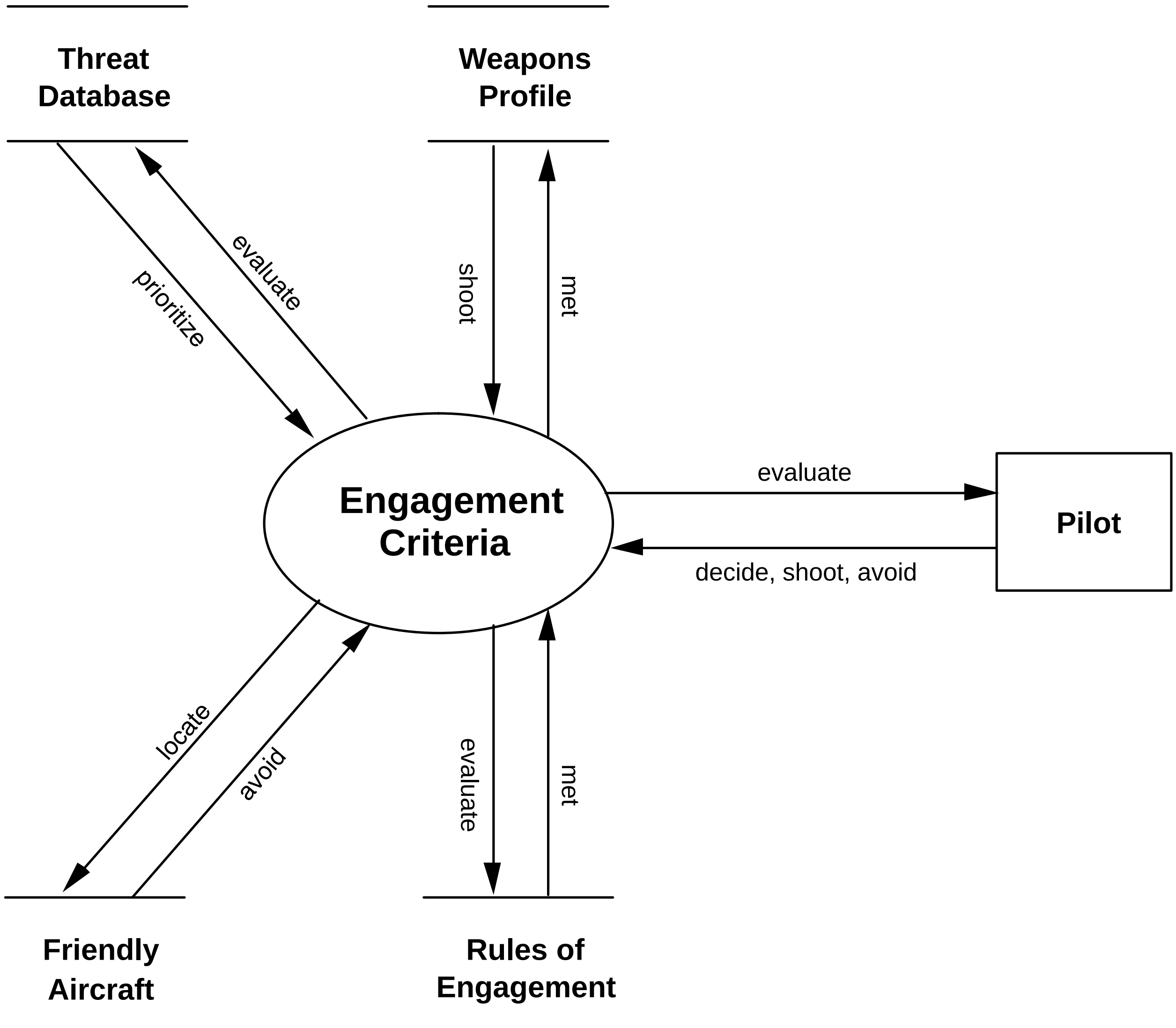
Note: SEAD is applied at only critical times to allow air forces to accomplish their mission without prohibitive interference from the enemy air defenses.

Figure D-43. Data flow diagram for offensive counterair (strike) SEAD state.



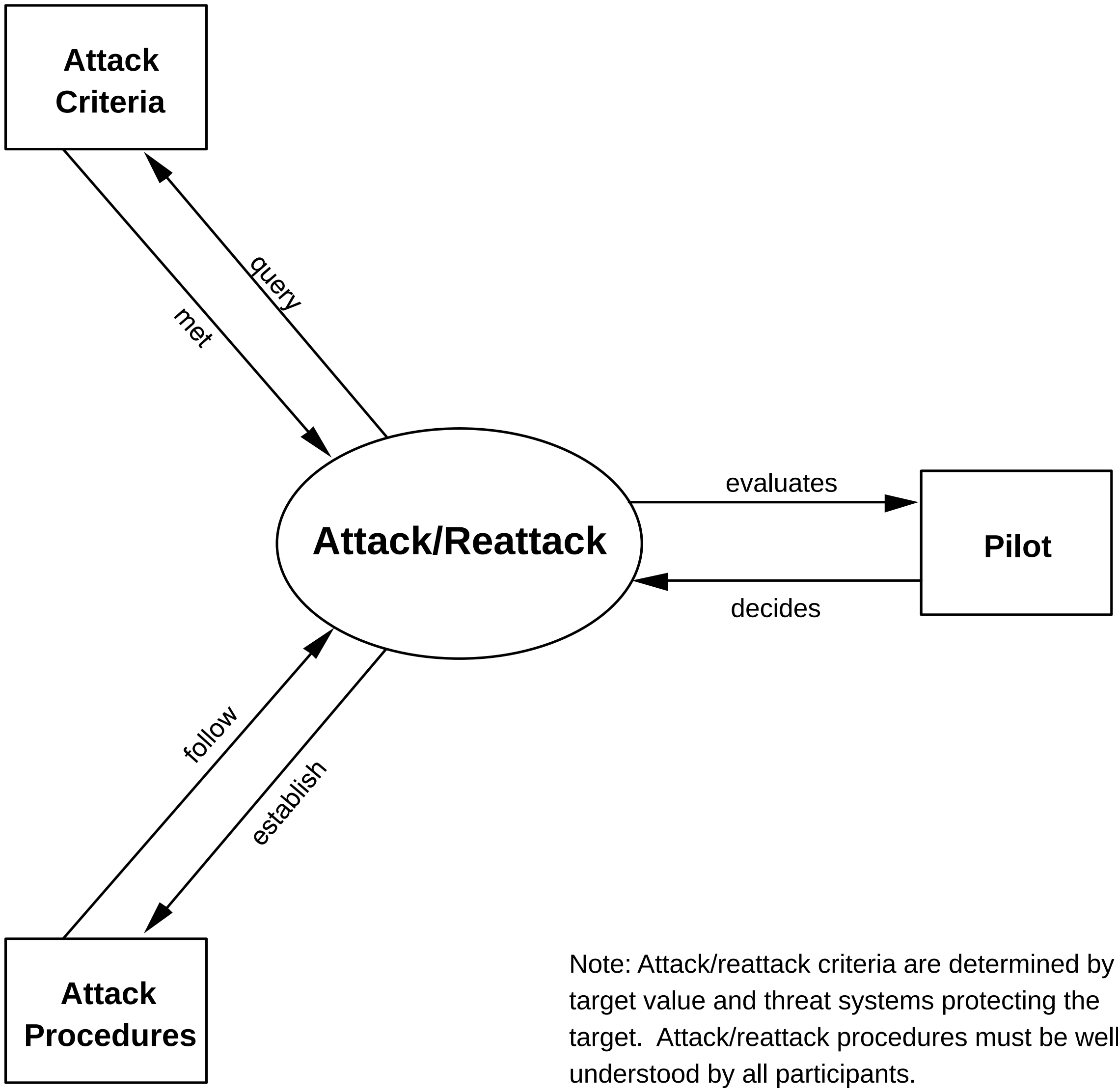
Note: Under “weapons free” criteria, it is assumed anything found on radar or visually is an enemy. The pilot is clear to engage. Under “weapons tight” criteria engagement is permitted only when cleared or when the ROE has been met. Engagement is authorized within assigned Fighter Engagement Zone (FEZ) only.

Figure D-44. Data flow diagram for offensive counterair (CAP) Control Procedures state.



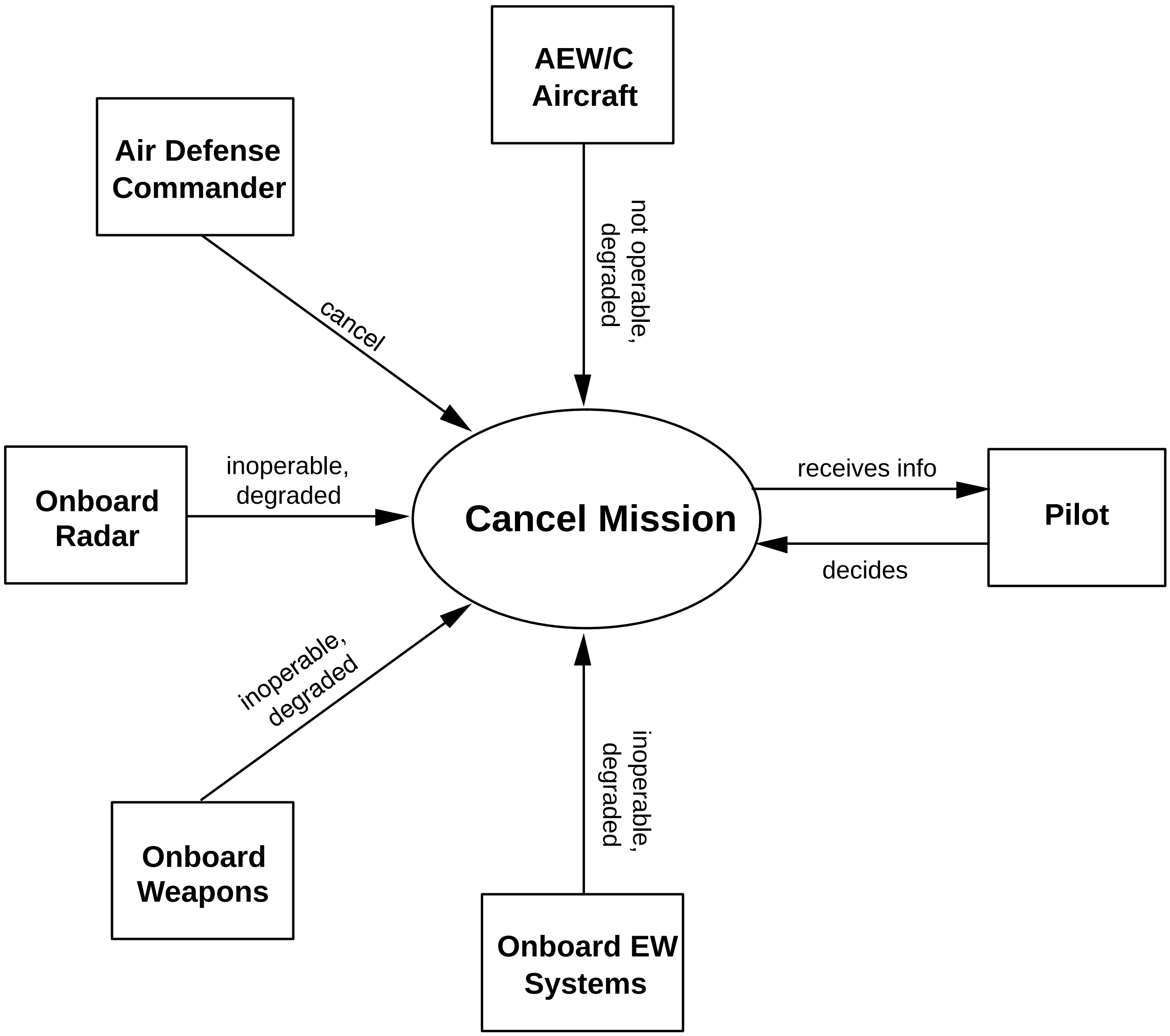
Note: These criteria ensure that the most serious threat will be engaged first, i.e., MIG-31 before MIG-17. Roe criteria must still be met, friendly forces avoided and, critically, the threat aircraft must be within the engagement envelope for the weapon selected.

Figure D-45. Data flow diagram for offensive counterair (CAP) Engagement Criteria state.



Note: Attack/reattack criteria are determined by target value and threat systems protecting the target. Attack/reattack procedures must be well understood by all participants.

Figure D-46. Data flow diagram for offensive counterair Attack/Reattack state.



Note: The Air Defense Commander cancel order and/or onboard weapons inoperable are mandatory mission termination criteria. All other sub-states require a pilot judgement and depend on criticality of the mission and the level of threat anticipated.

Figure D-47. Data flow diagram for offensive counterair operations Cancel Mission state.

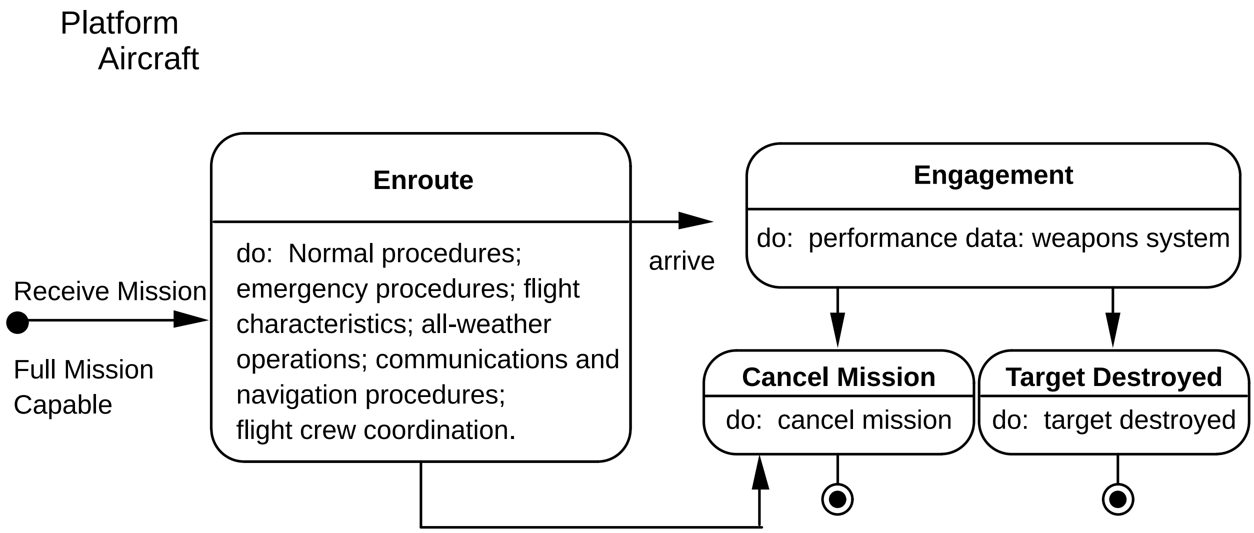
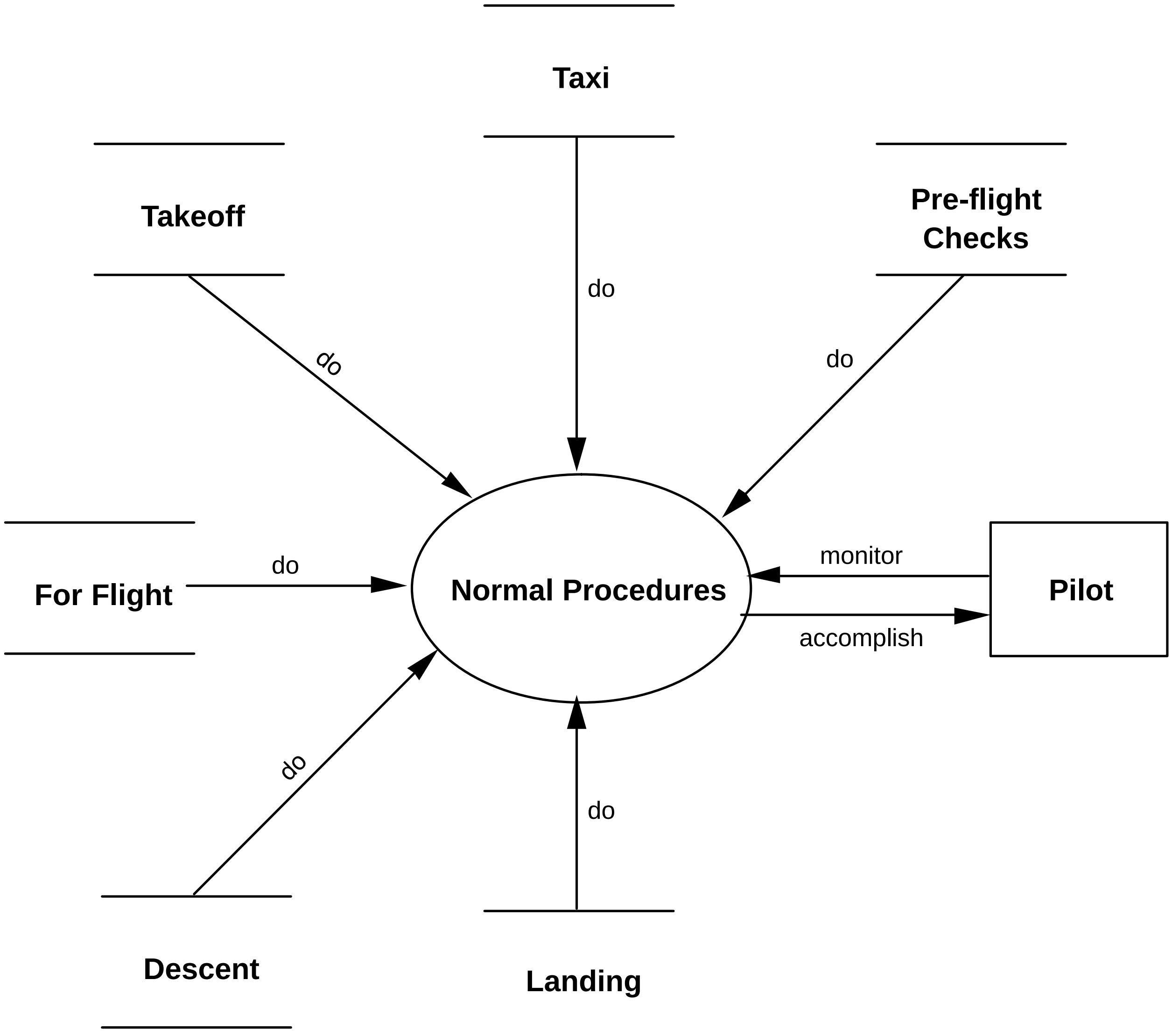
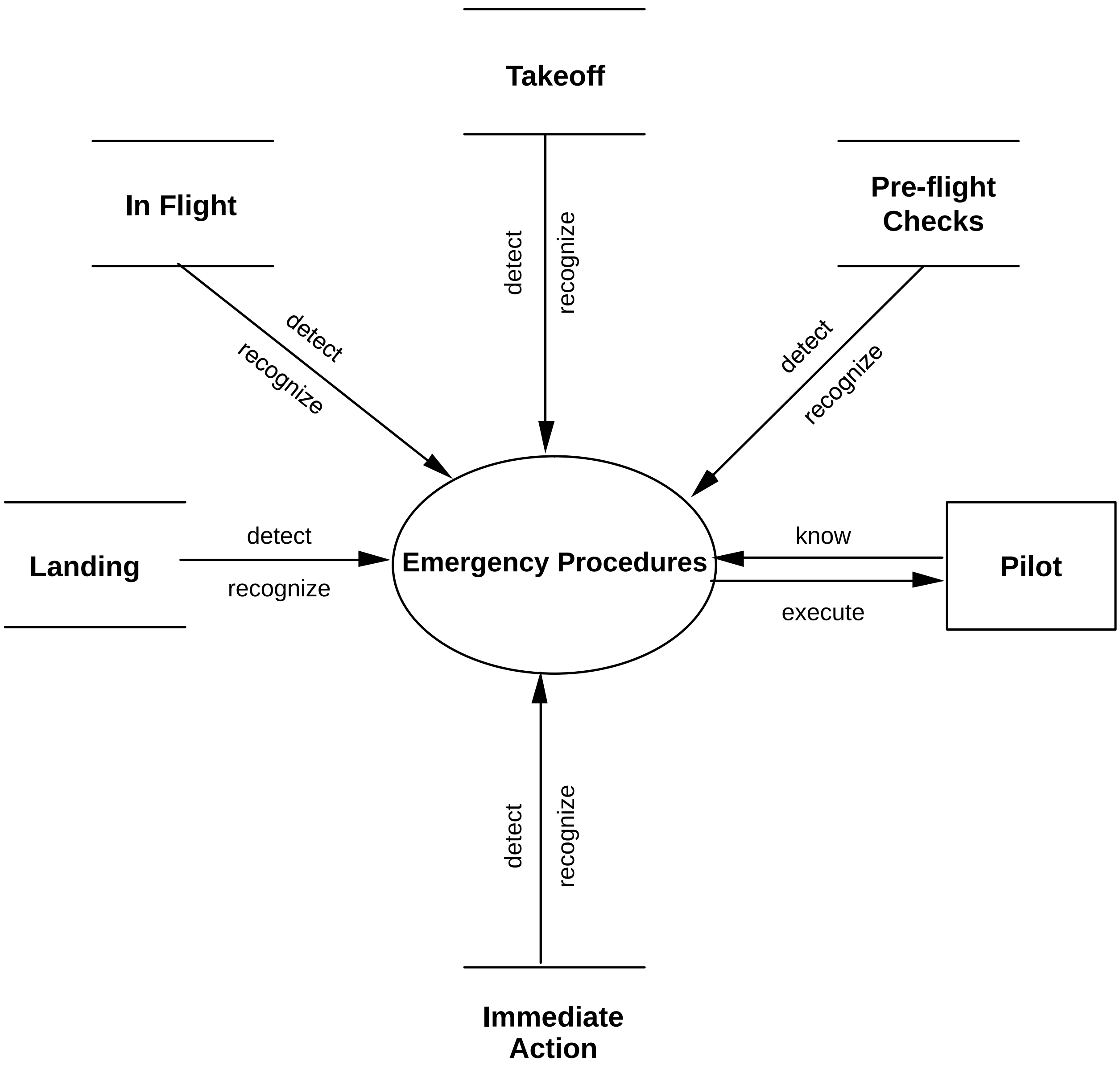


Figure D-48. State diagram for aircraft mission.



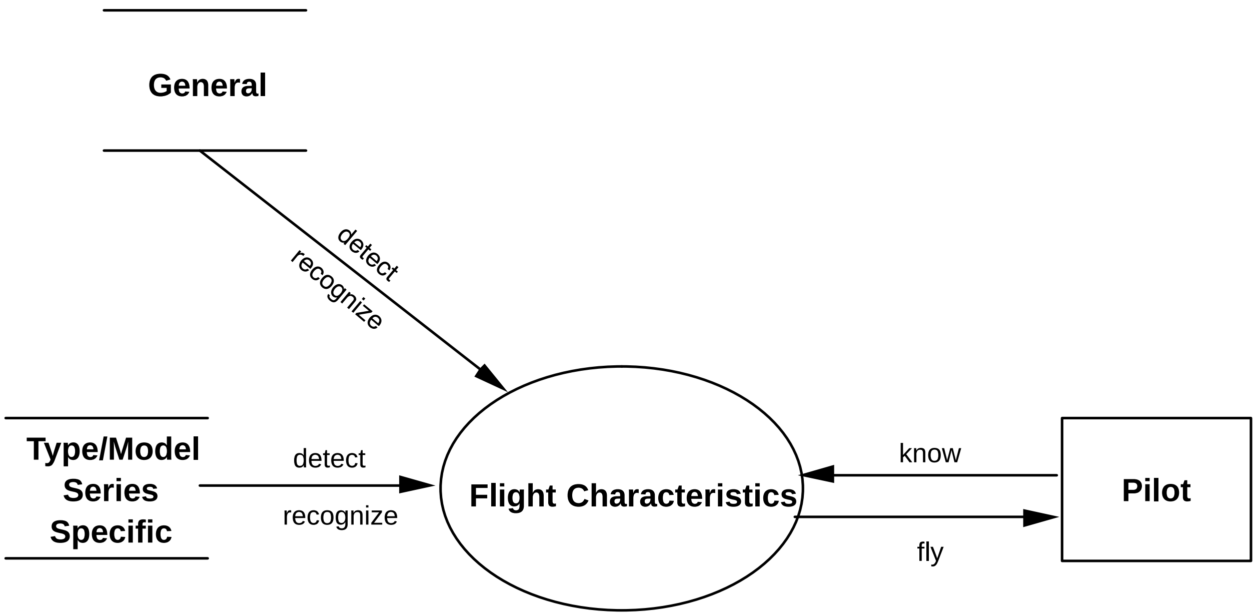
Each aircraft has very specific procedures contained in the individual data stores for each type, model, series aircraft.

Figure D-49. Data flow diagram for aircraft Normal Procedures state.



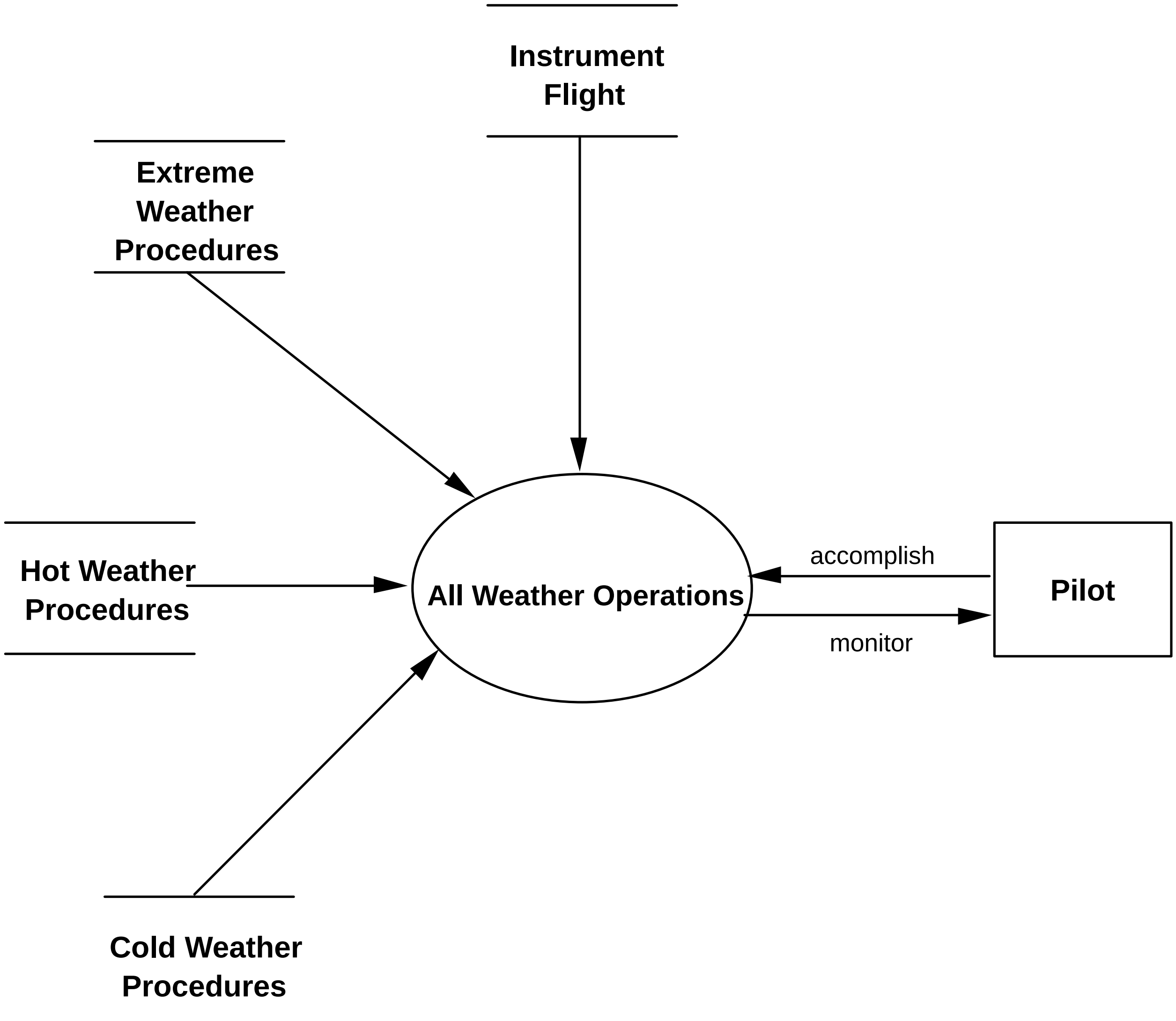
Note: Each aircraft has very specific procedures contained in the individual data stores for each type, model, and series aircraft.

Figure D-50. Data flow diagram for aircraft Emergency Procedures state.



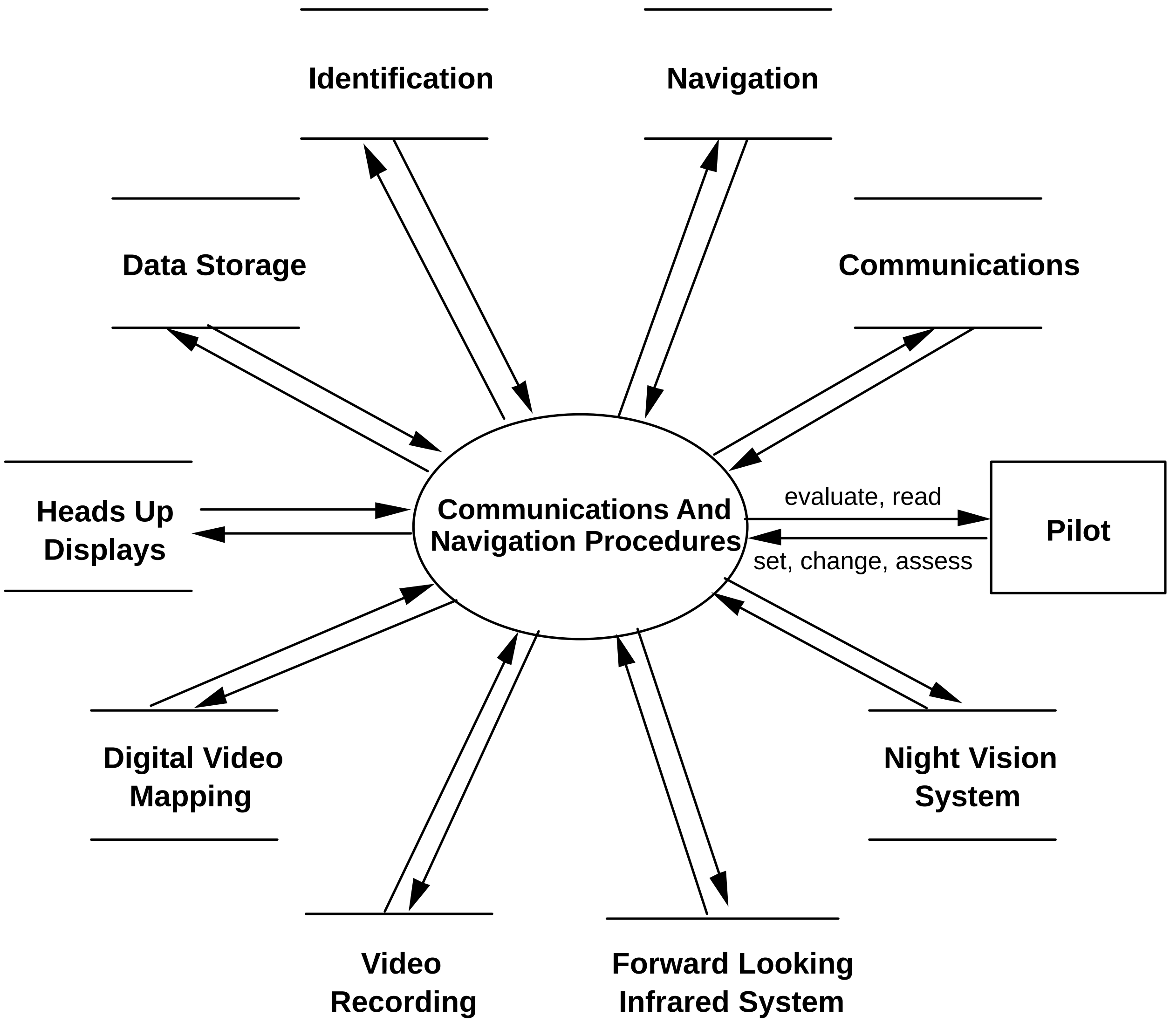
Note: All aircraft share general flight characteristics that vary only in the conditions that cause effects to be known and recognized, e.g., take-off speed, stall speed. Similarly, each aircraft has specific characteristics that define its capabilities and limits, e.g., vertical takeoff and landing for the AV-8.

Figure D-51. Data flow diagram for aircraft Flight Characteristics state.



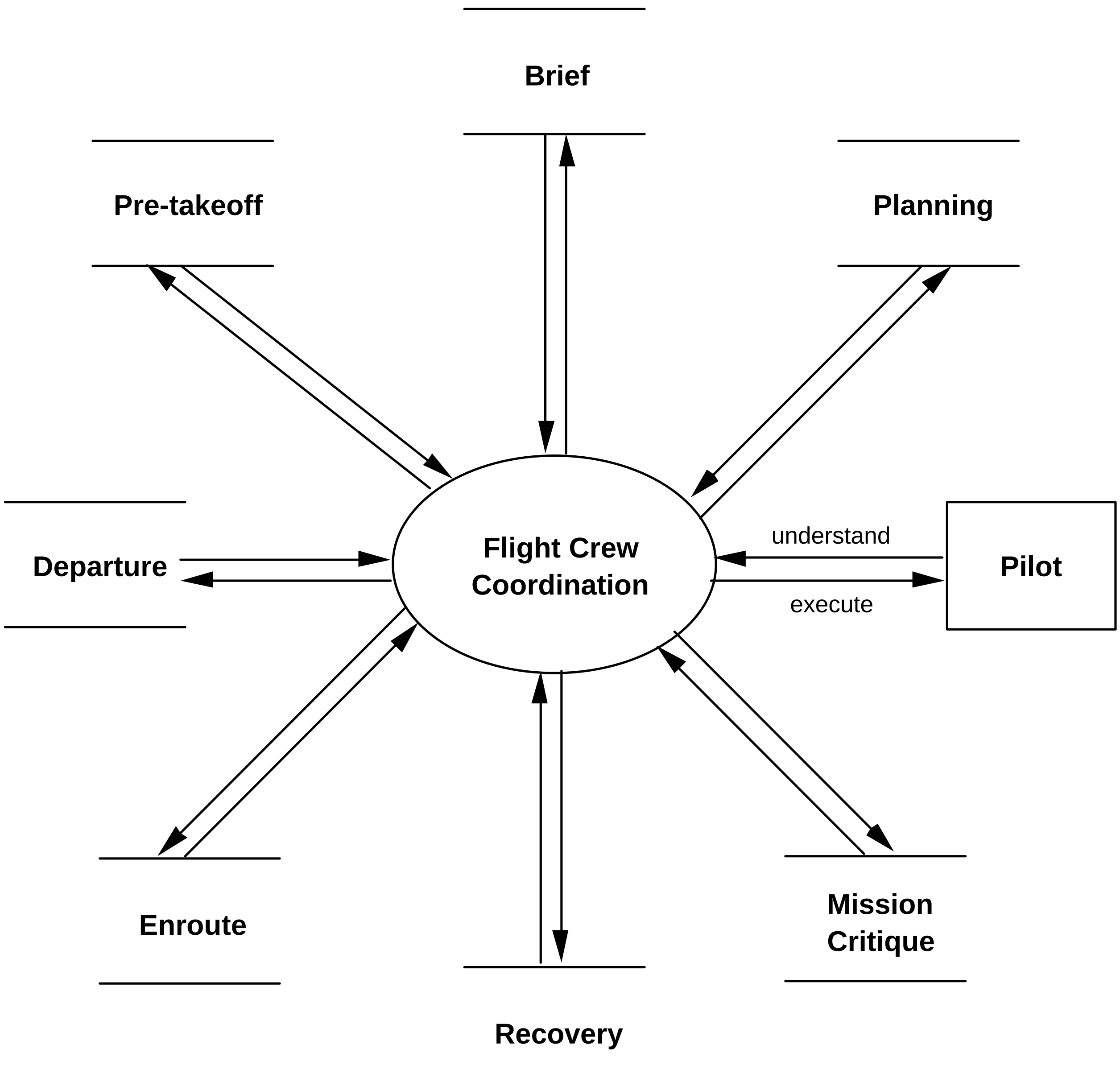
Note: All aircraft have model-specific procedures to successfully fly in each of the four specific cases listed.

Figure D-52. Data flow diagram for aircraft All Weather Operations state.



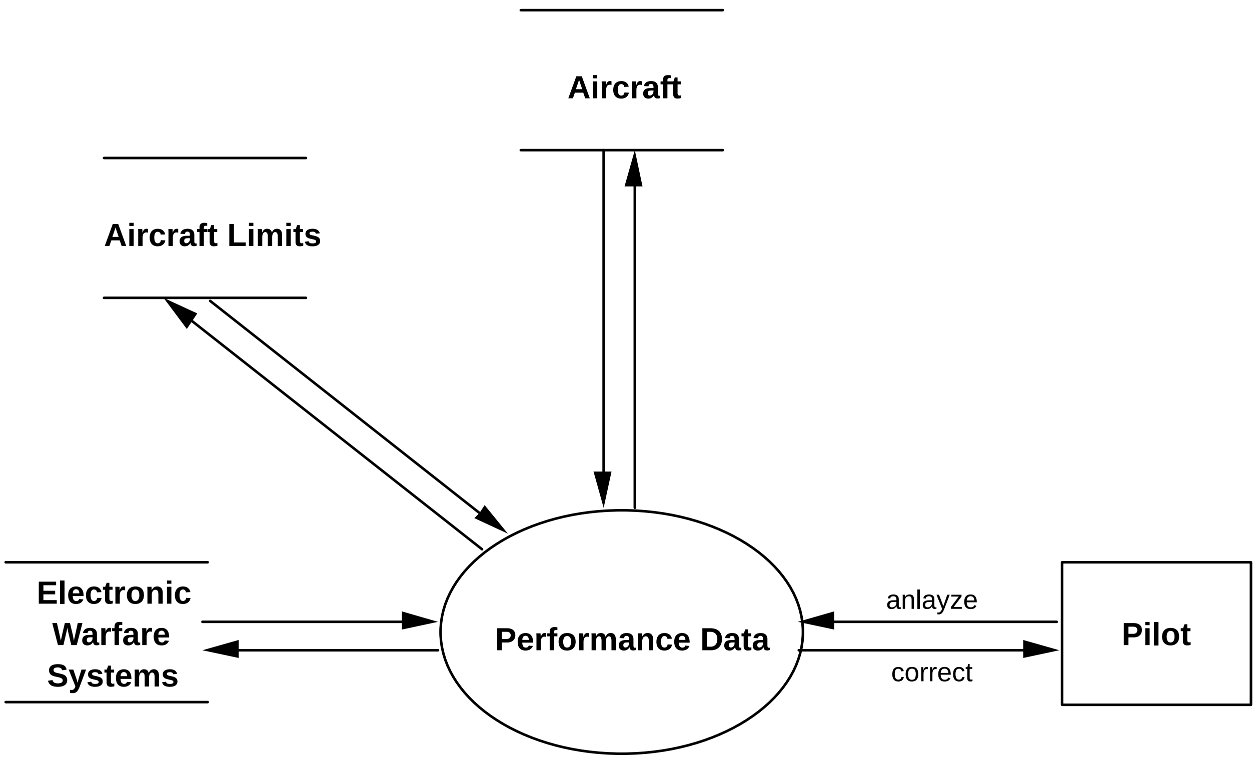
Equipment and procedures vary from model/series, but all have at least some level of sophistication. Pilots set and change frequencies and equipment to comply with requirements; use equipment displays to navigate and locate targets, zones of action, and in a growing number of aircraft, videotape critical portions of the mission.

Figure D-53. Data flow diagram for aircraft Communications and Navigation Procedures state.



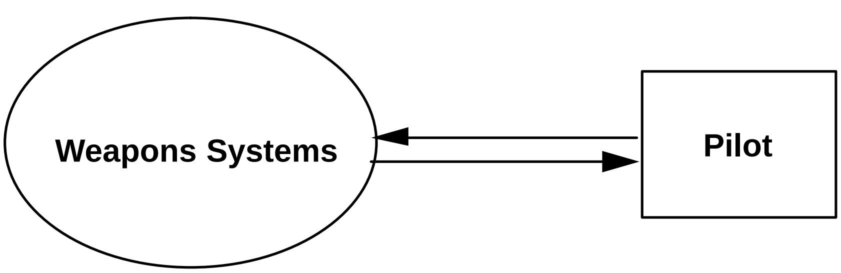
Note: Critical to mission accomplishment. Each crew member must understand and execute his responsibilities in each and every data state to accomplish the mission.

Figure D-54. Data flow diagram for aircraft Flight Crew Coordination state.



Note: Individual aircraft tactical manuals (parts classified) provide detailed information.

Figure D-55. Data flow diagram for aircraft Performance Data state.



Note: Weapons available vary by aircraft. Specific tactical manuals list weapon carriage and delivery parameters and limits.

Figure D-56. Data flow diagram for aircraft Weapons Systems state.

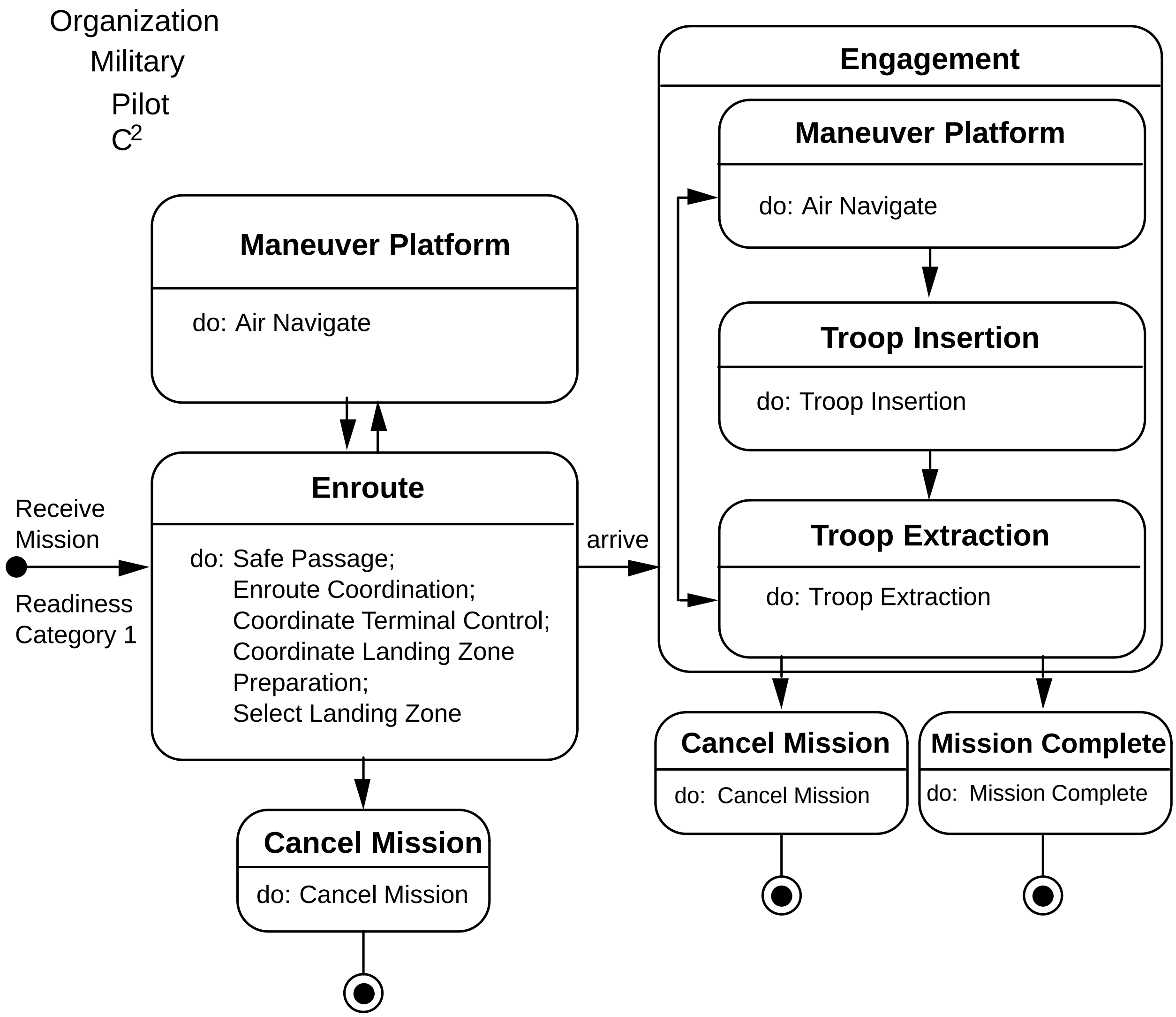


Figure D-57. State diagram for the mission of helicopterborne assault.

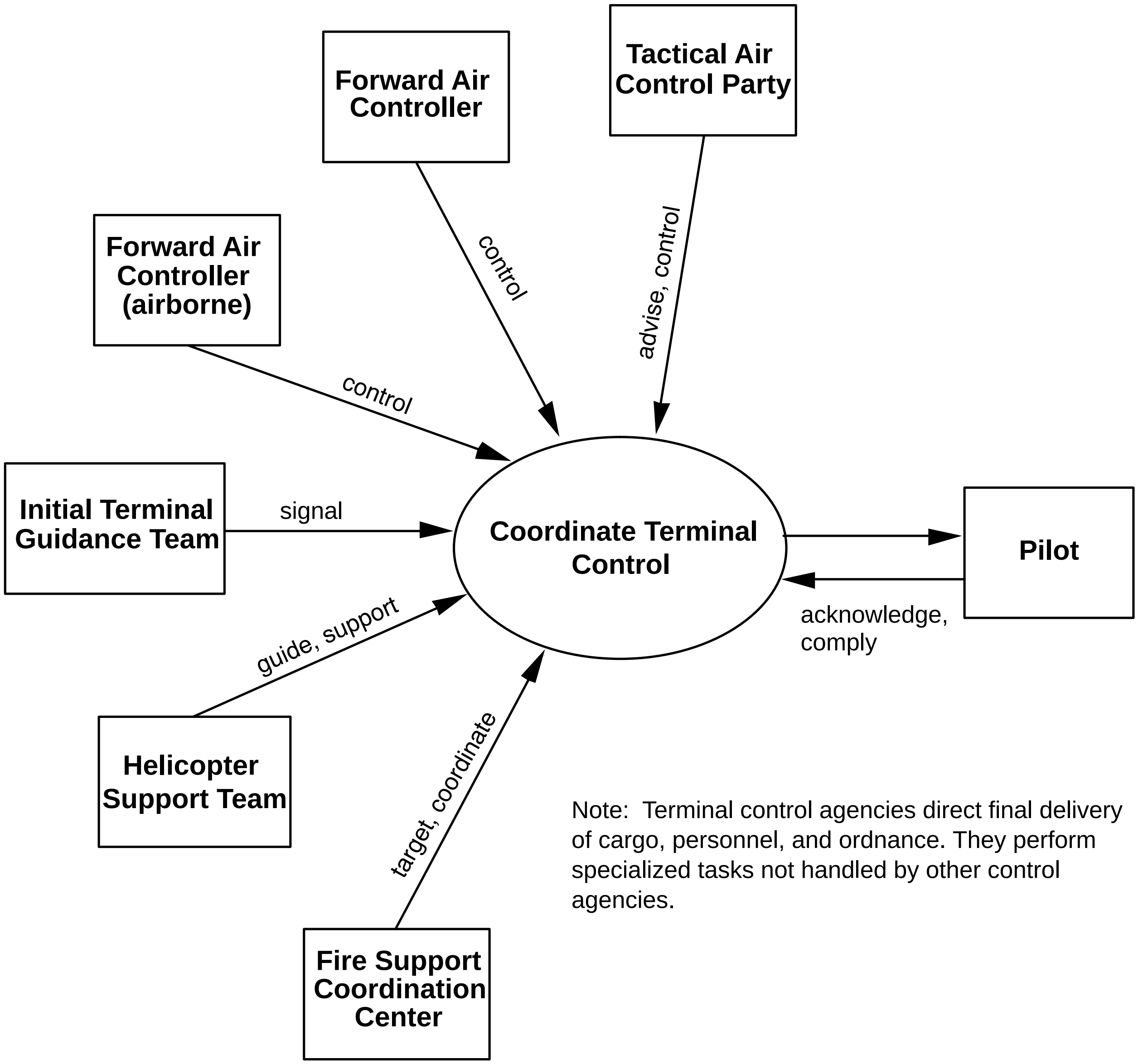
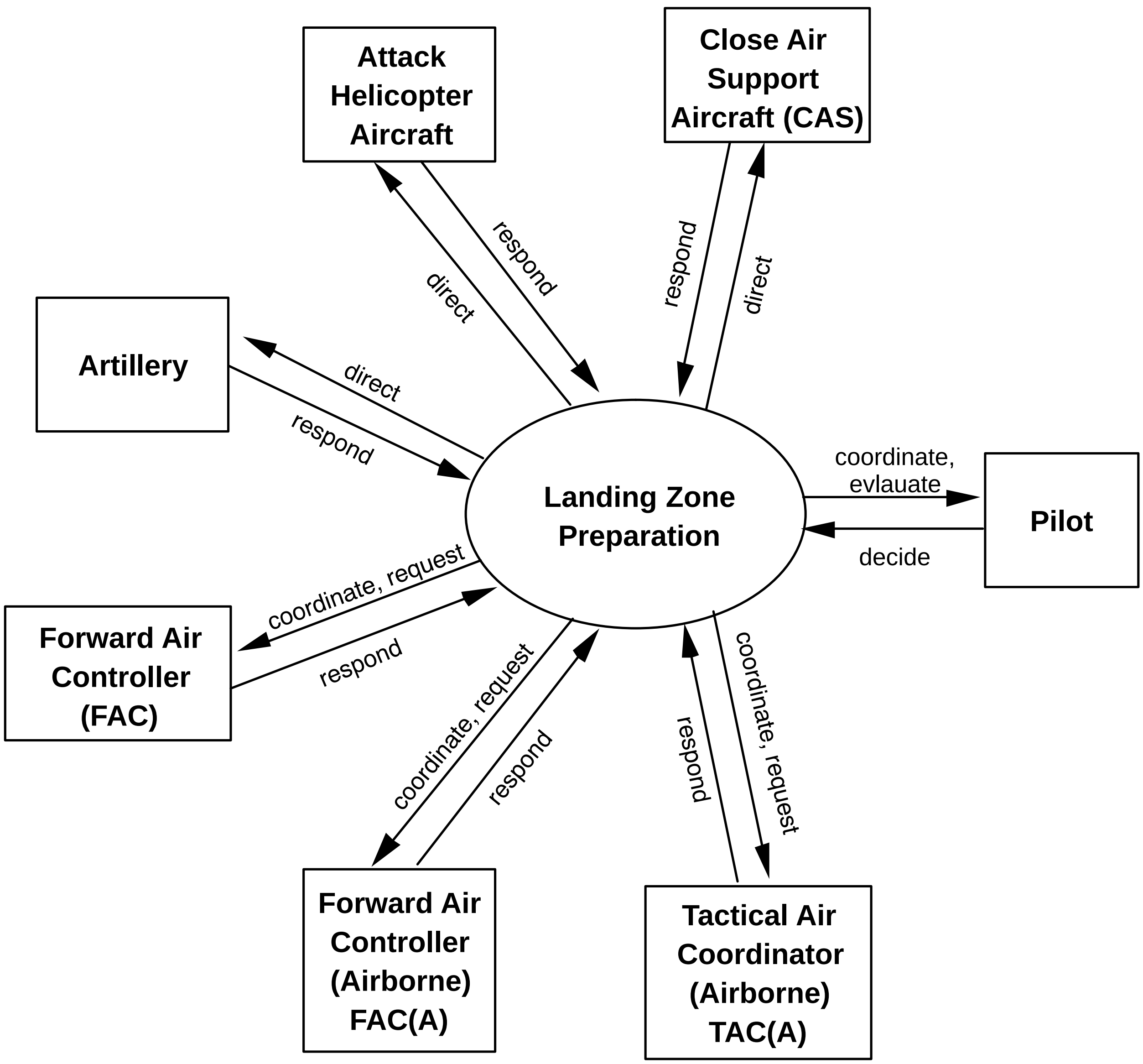
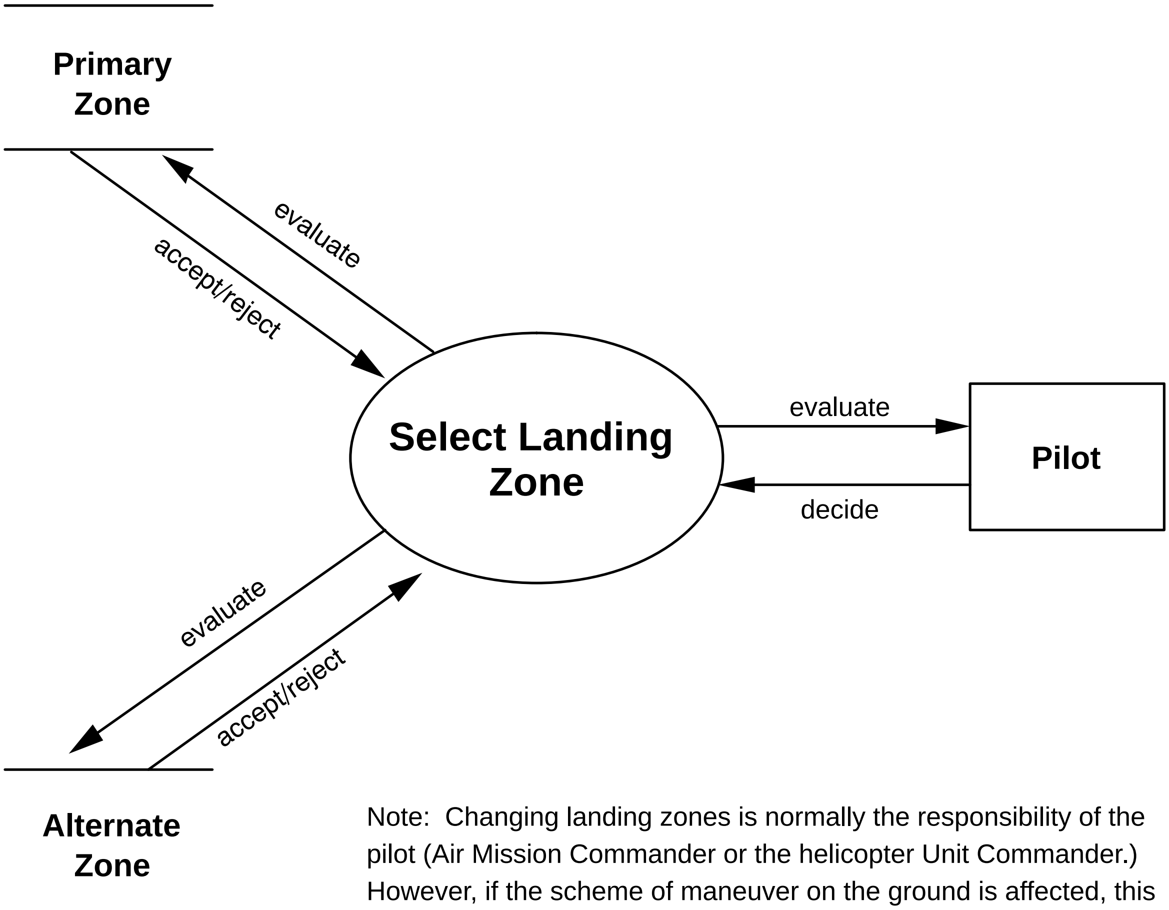


Figure D-58. Data flow diagram for Coordinate Terminal Control state.



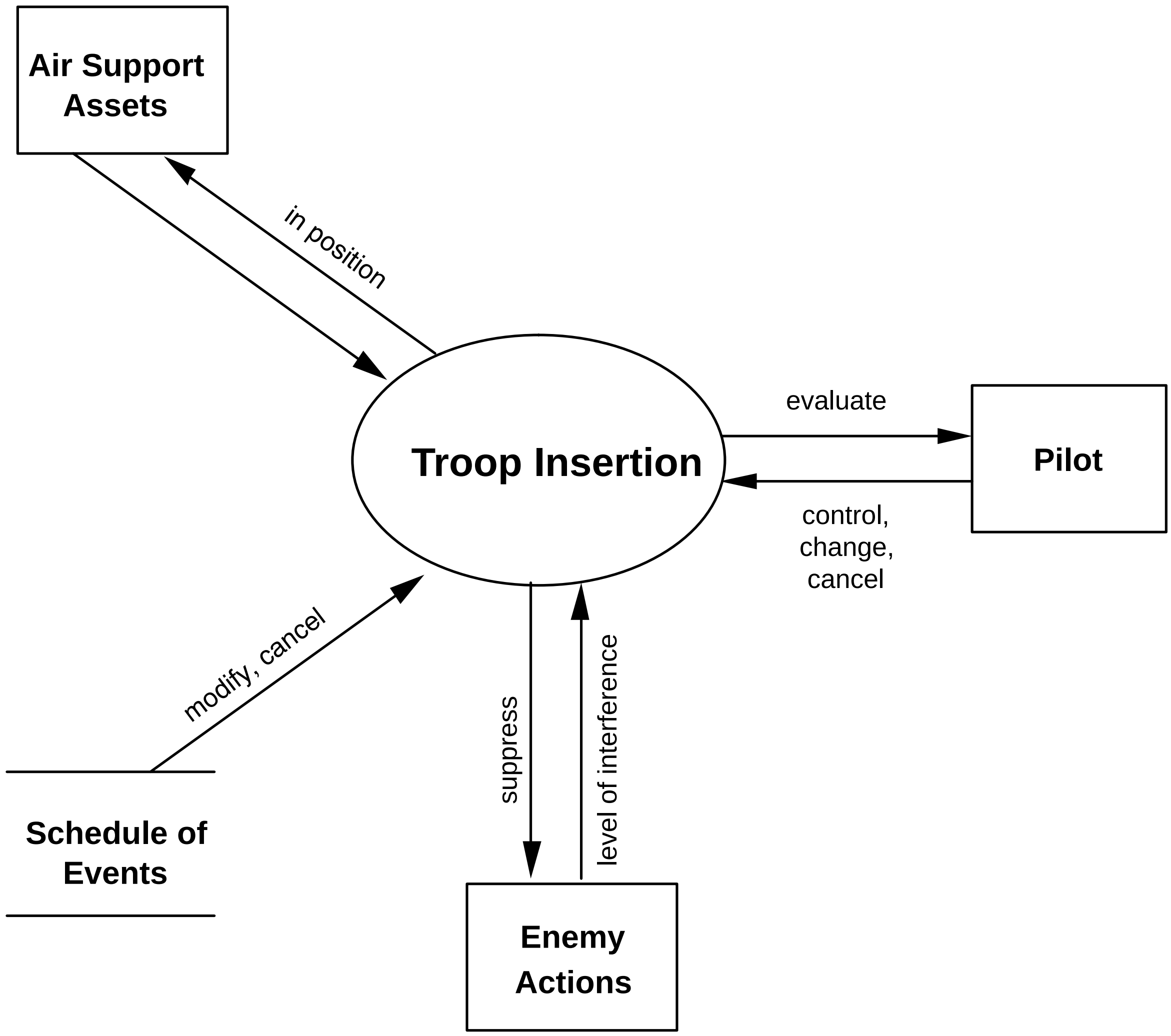
Note: Prior to commencing the assault, the pilot (Air Mission Commander) must determine if the preparation of the landing zone has been effective. Additional preparation is normally done through the FAC, FAC(A), or DAC(A). In their absence, the pilot will call for and adjust fire from artillery/attack helicopters or CAS aircraft.

Figure D-59. Data flow diagram for helicopterborne assault Landing Zone Preparation state.



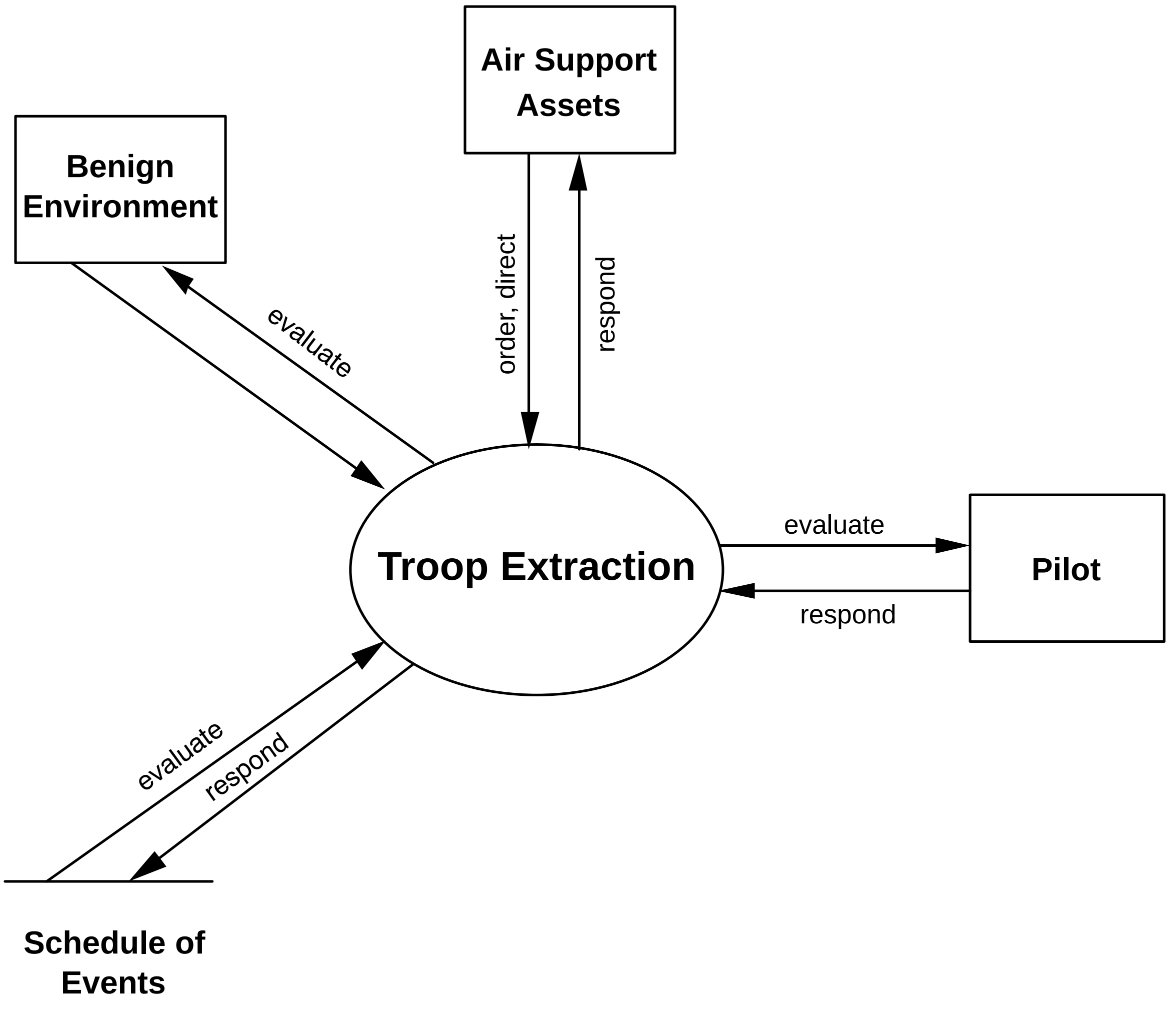
Note: Changing landing zones is normally the responsibility of the pilot (Air Mission Commander or the helicopter Unit Commander.) However, if the scheme of maneuver on the ground is affected, this authority cannot be delegated below the highest unit affected.

Figure D-60. Data flow diagram for helicopterborne assault Select Landing Zone state.



Note: The Pilot (Air Mission Commander) ensures the fixed and rotory wing air support assets are at their proper initial points, that the proper sequence of events is adhered to; if enemy actions are adversely affecting mission accomplishment, he must delay or cancel the insertion.

Figure D-61. Data flow diagram for helicopterborne assault Troop Insertion state.



Note: Under normal circumstances, extractions will be conducted after the mission has been accomplished (benign environment). In that event the extraction is nothing more than an administrative movement. In the event of enemy interference, the extraction is controlled like an insertion, i.e., assets sufficient to suppress fire and safely remove the force are brought to bear on the enemy.

Figure D-62. Data flow diagram for helicopterborne assault Troop Extraction state.

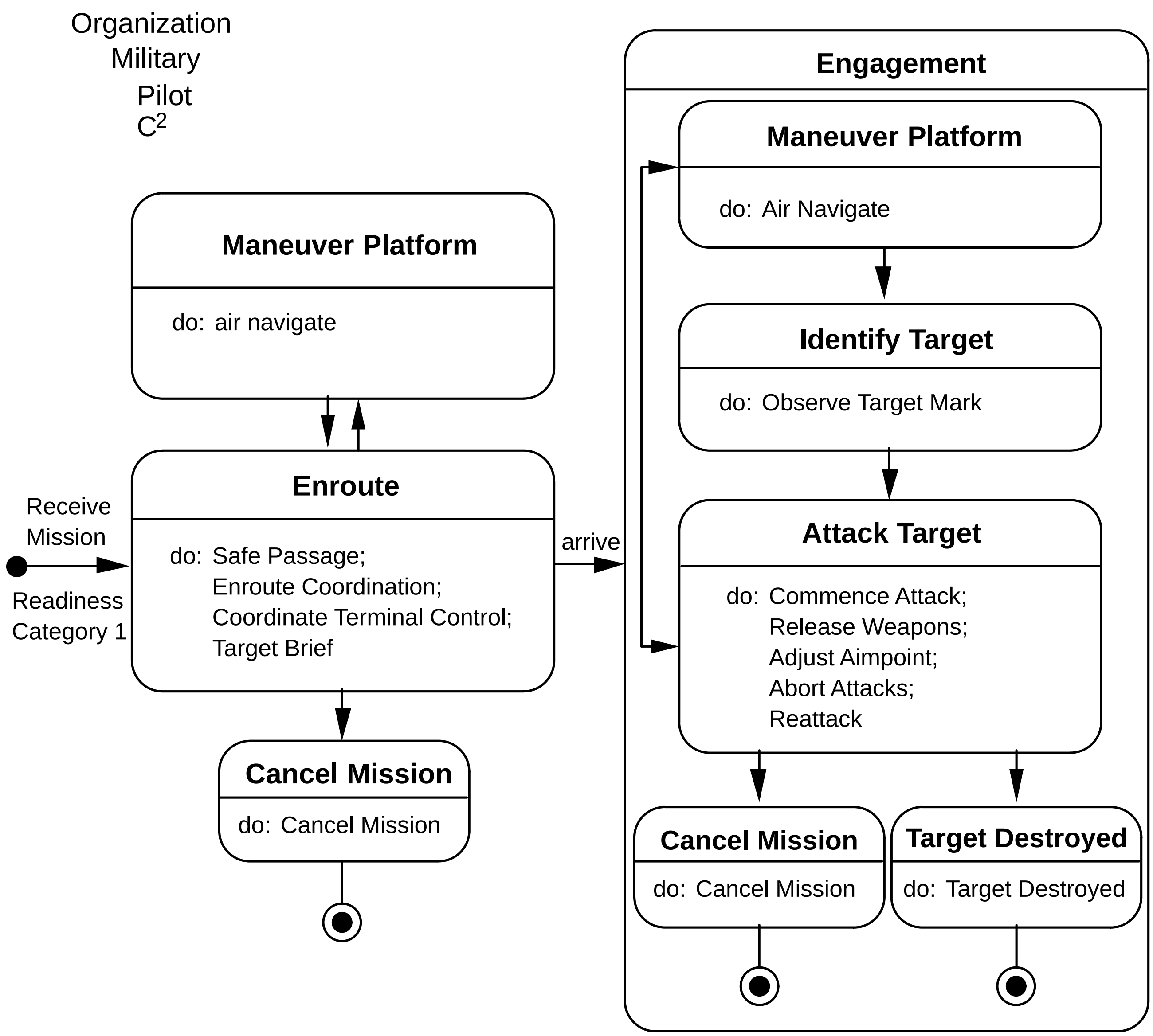
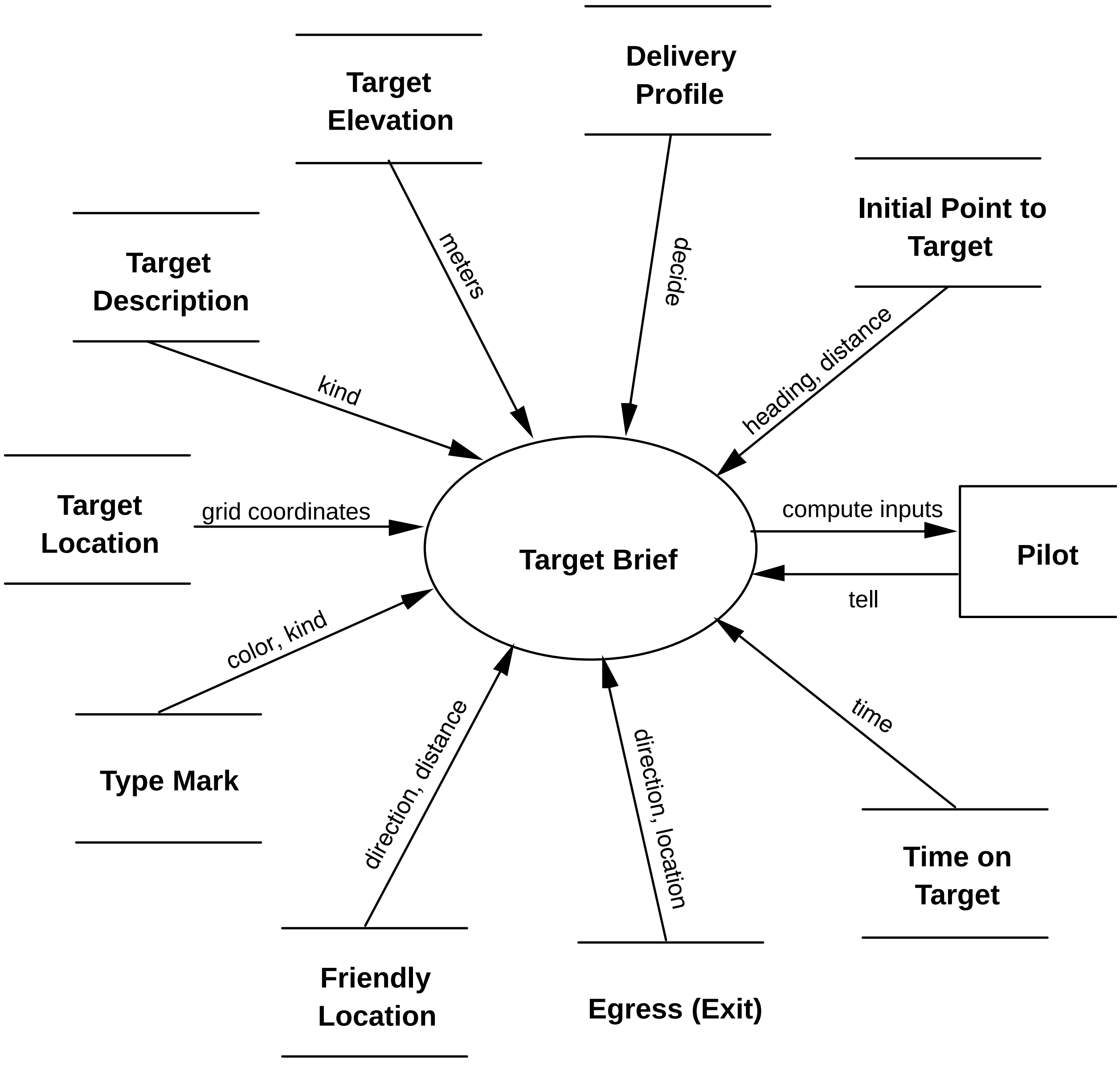
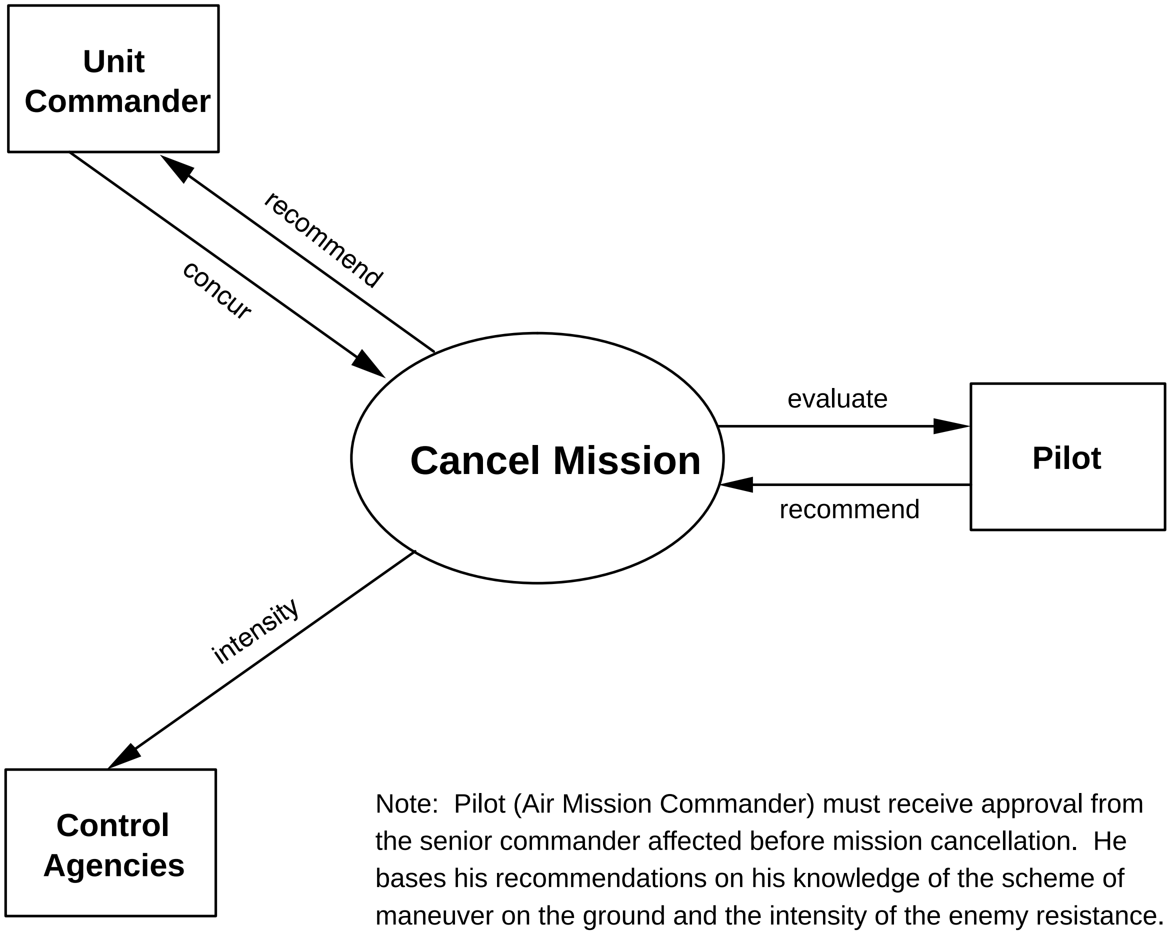


Figure D-63. State diagram for the mission of attack helicopter operations.



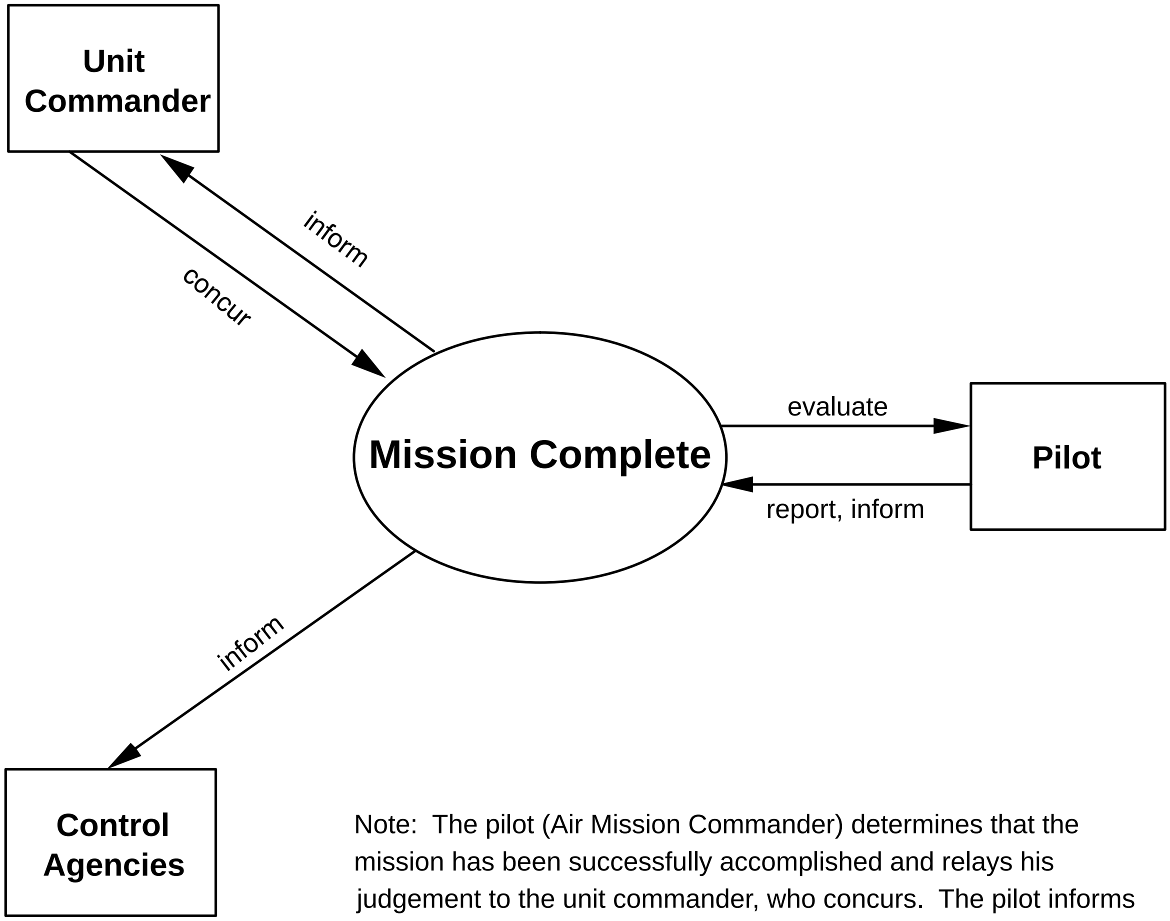
Note: The controlling agency will formulate a “FAC Briefing Card” that includes these data.

Figure D-64. Data flow diagram for attack helicopter operations Target Brief state.



Note: Pilot (Air Mission Commander) must receive approval from the senior commander affected before mission cancellation. He bases his recommendations on his knowledge of the scheme of maneuver on the ground and the intensity of the enemy resistance.

Figure D-65. Data flow diagram for helicopterborne assault Cancel Mission state.



Note: The pilot (Air Mission Commander) determines that the mission has been successfully accomplished and relays his judgement to the unit commander, who concurs. The pilot informs all control agencies that the mission has been accomplished, where the troops were inserted/extracted from, and at what time.

Figure D-66. Data flow diagram for helicopterborne assault Mission Complete state.

Organization (Soldier)
Military
Weapon (Individual/Crew Served)
C^2

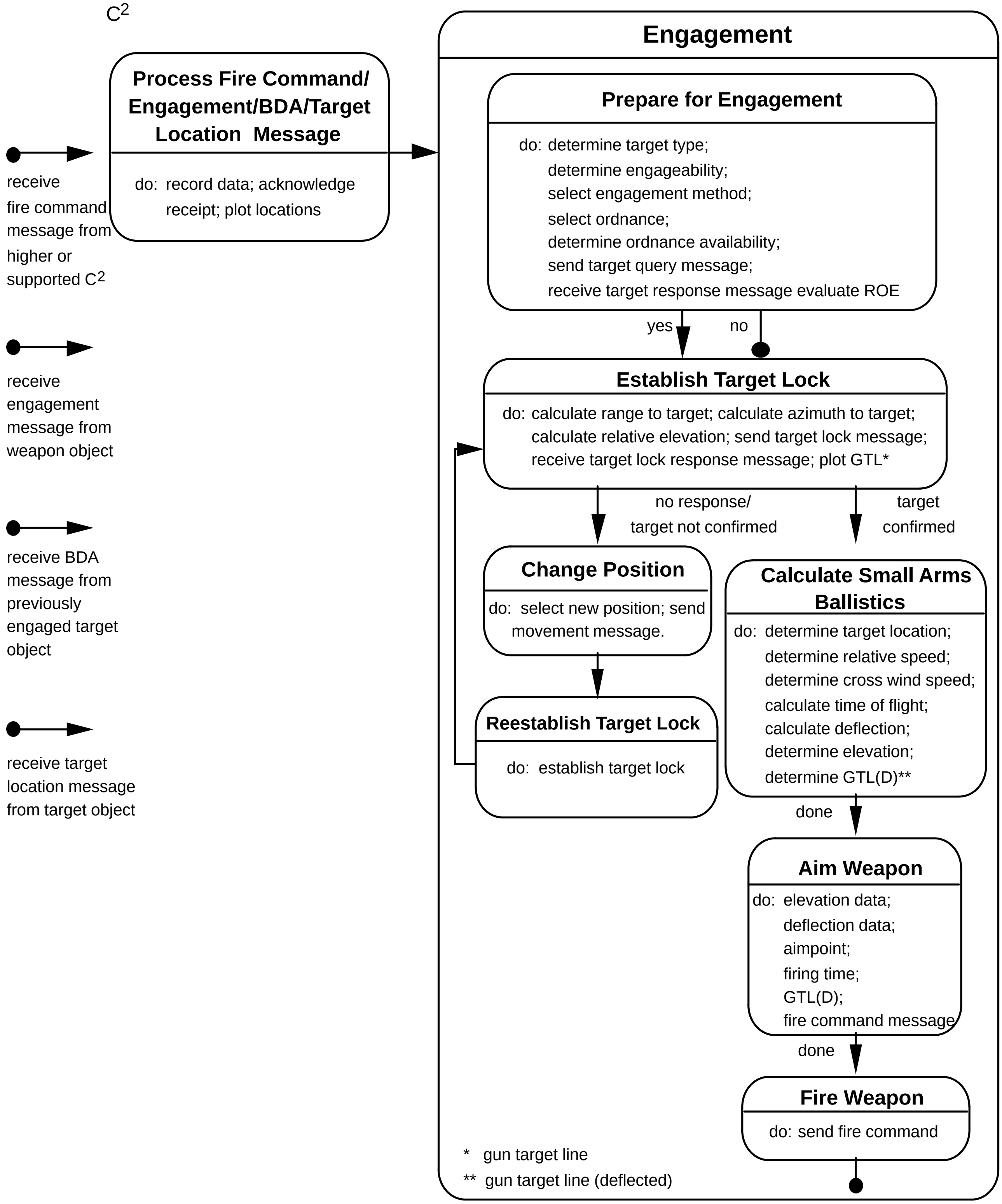


Figure D-67. State diagram for Execute Small Arms Direct Fire engagement.

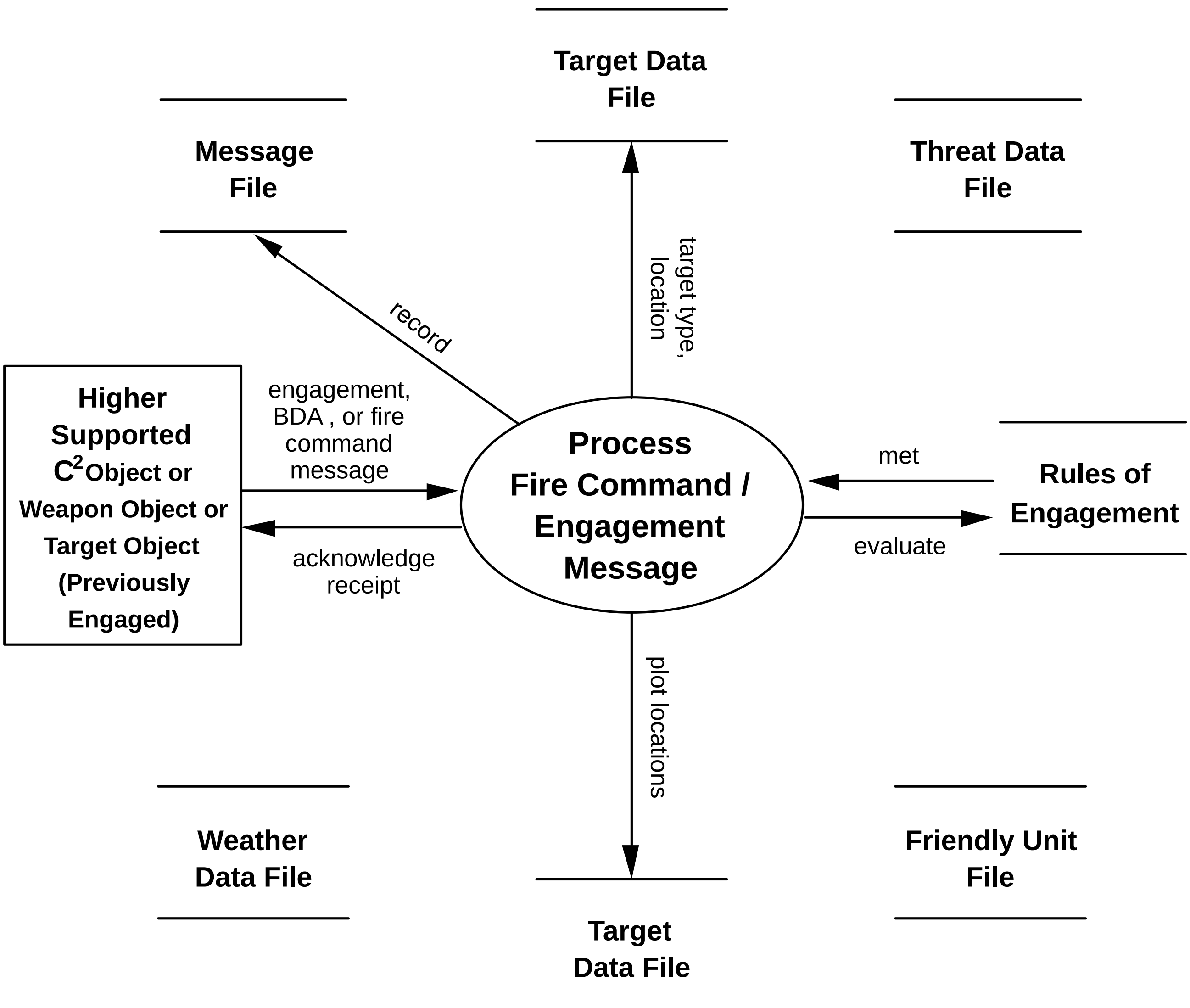
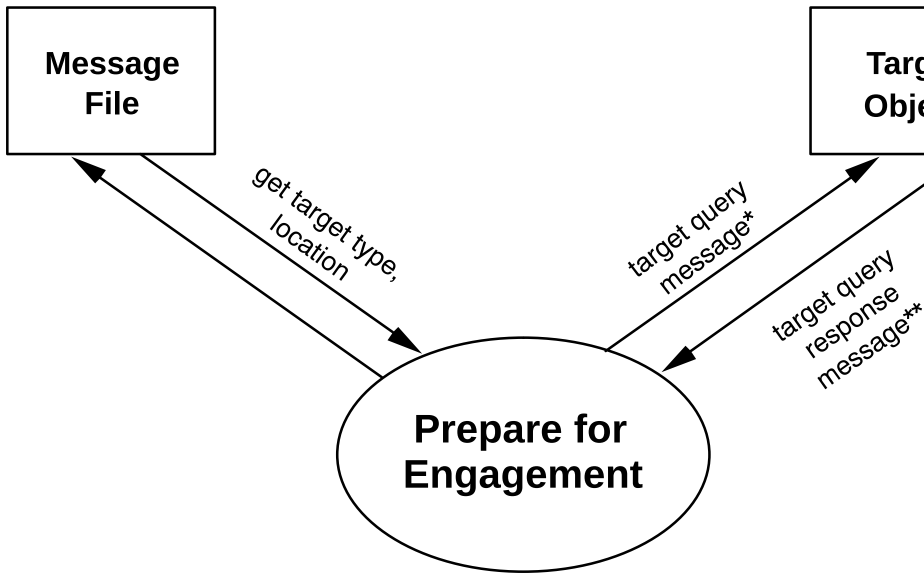


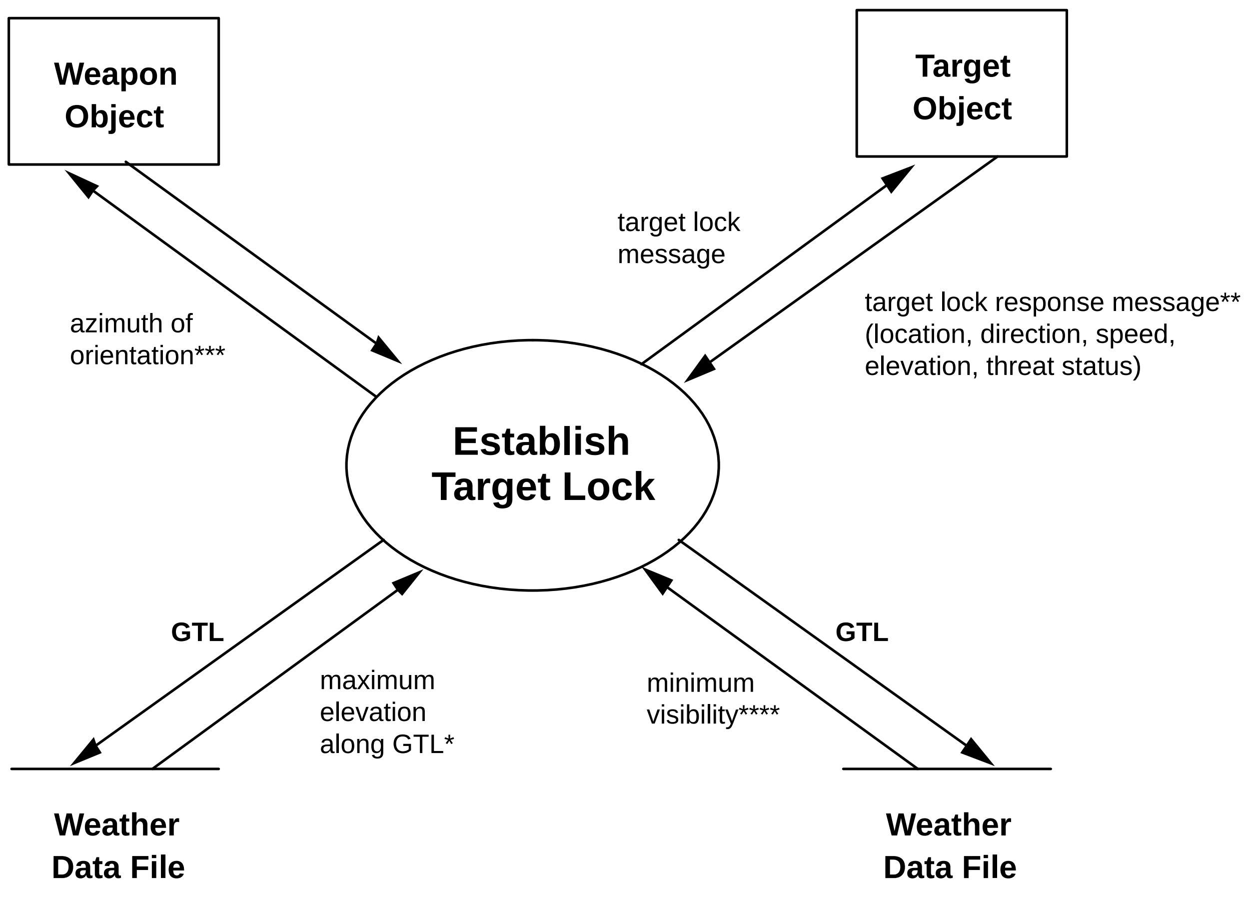
Figure D-68. Data flow diagram for Process Fire Command/Engagement Messages, Execute Small Arms Direct Fire engagement.



* Target query message asks target object its identity, vulnerability (ordnance look-up table) based on the object's lethality table (what it can engage with). If no match, engagement ceases.

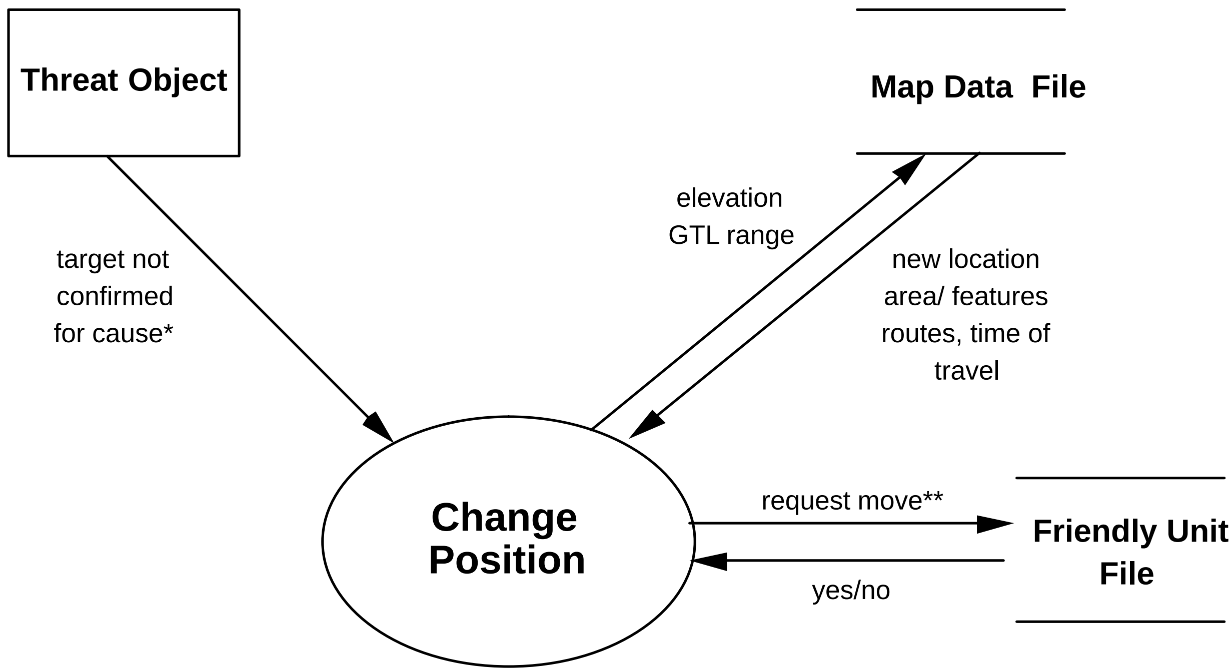
** Target query response message confirms weapons/ordnance to which the target is vulnerable (i.e., you can fire at a tank with an M–2 .50 cal machine gun and it will not affect it, but a 120 mm tank main gun round will. Both are available on a M1A2 Abrams MBT.)

Figure D-69. Data flow diagram for Prepare for Engagement, Execute Small Arms Direct Fire engagement.



* If elevation along GTL exceeds LOS betweenweapon C^2 and target, target is not confirmed.
** If range to target exceeds max effective range of weapon, target is not confirmed.
*** If azimuth to target exceeds traverse of weapon system (+/–) azimuth of direction, target is not confirmed.
**** If range to target exceeds minimum visibility along GTL, target is not confirmed.

Figure D-70. Data flow diagram for Establish Target Lock, Execute Small Arms engagement.



* Intervening elevation, excessive range, or low visibility.

** Object may be constrained in movement, or new location may exceed permitted movement time, be “out of area,” or be occupied by another C^2 entity.

Figure D-71. Data flow diagram for Change Position, Execute Small Arms engagement.

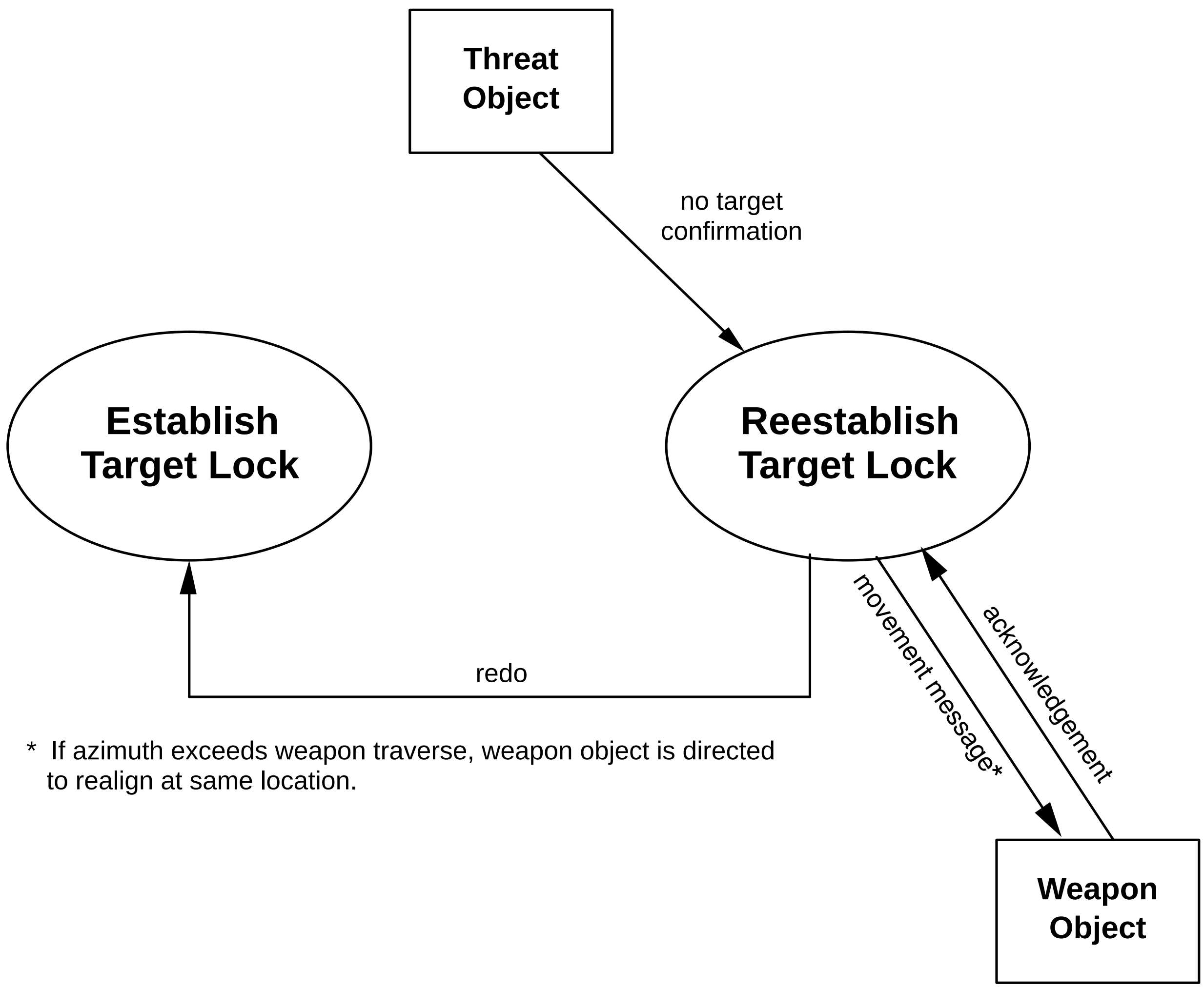
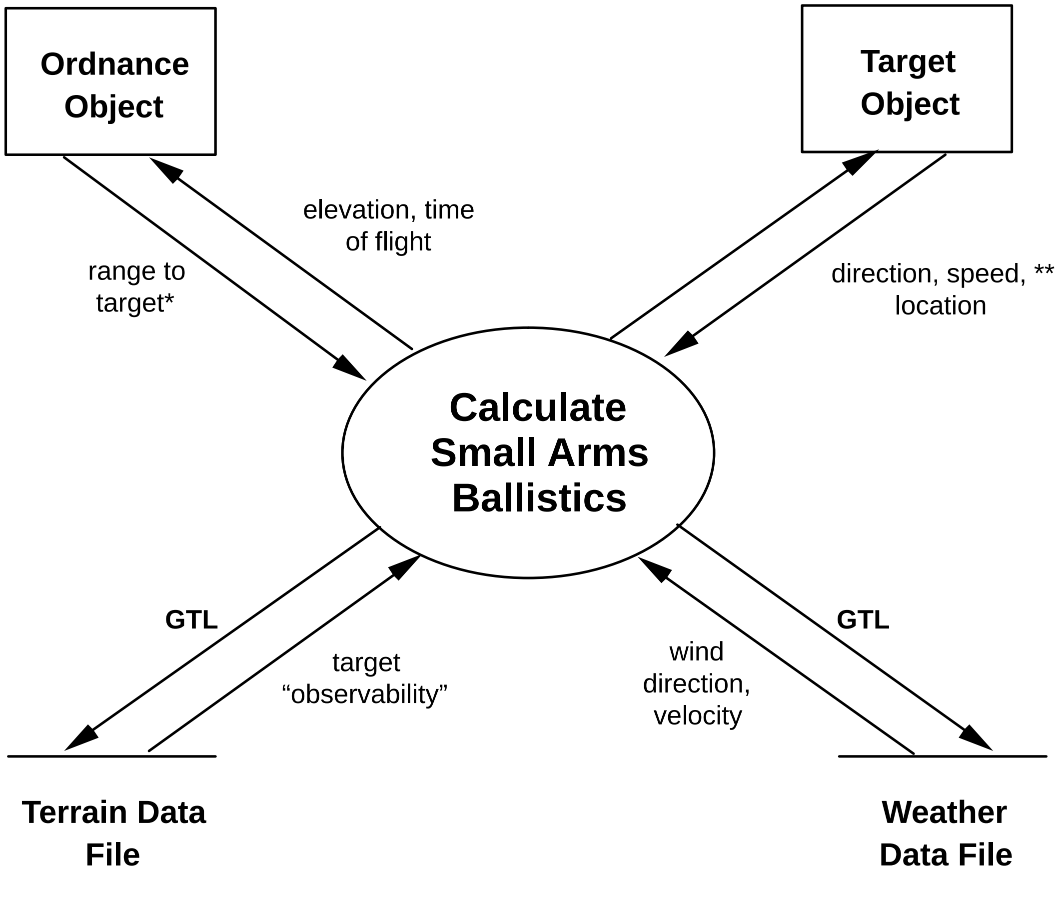
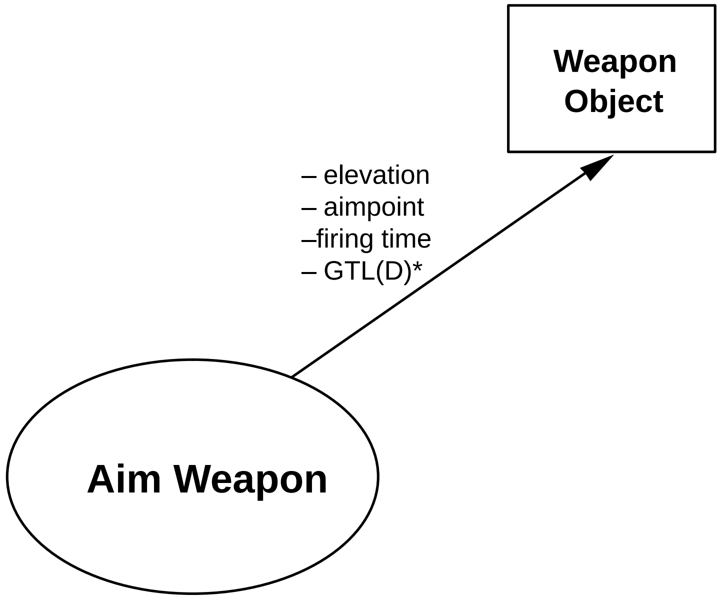


Figure D-72. Data flow diagram for Reestablish Target Lock, Execute Small Arms Direct Fire engagement.



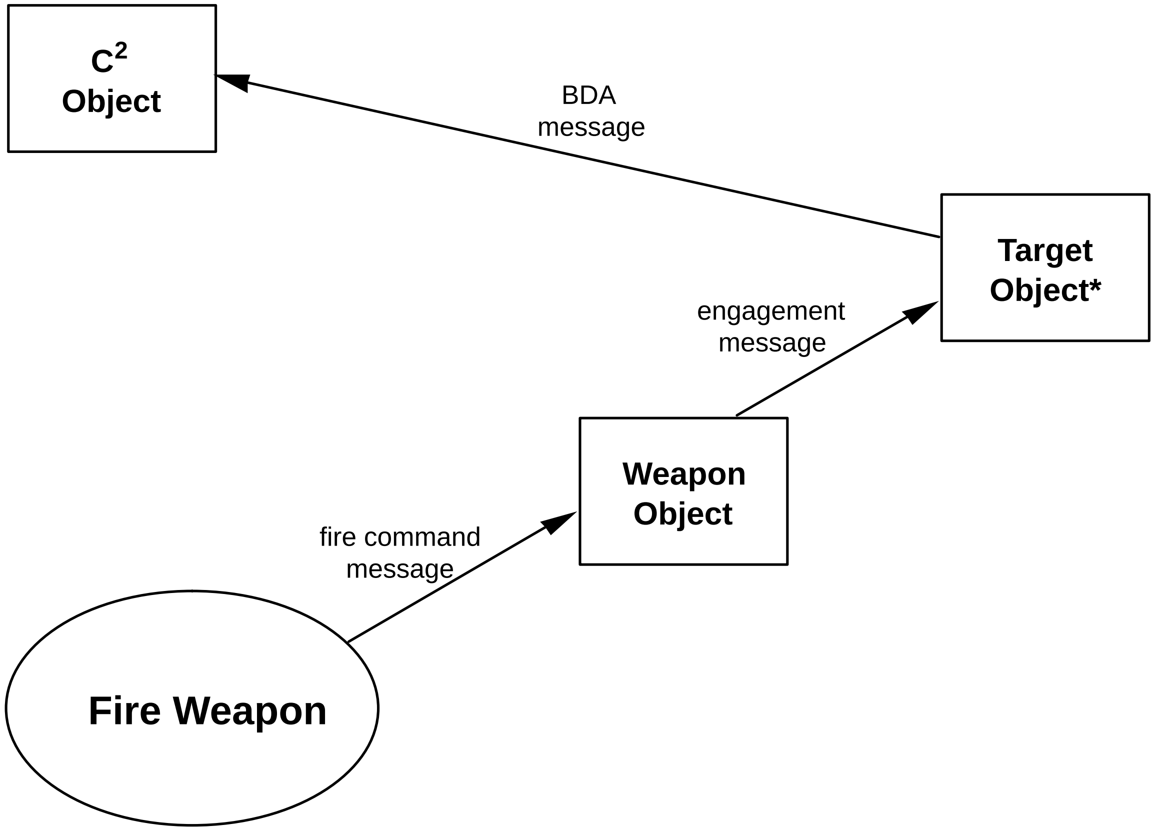
* Ordnance object is queried for required elevation and time of flight at given range to target.
** Relative speed of target is calculated using the actual speed factored by angle of incidence to the GTL.

Figure D-73. Data flow diagram for Calculate Small Arms Ballistics, Execute Small Arms Direct Fire engagement.



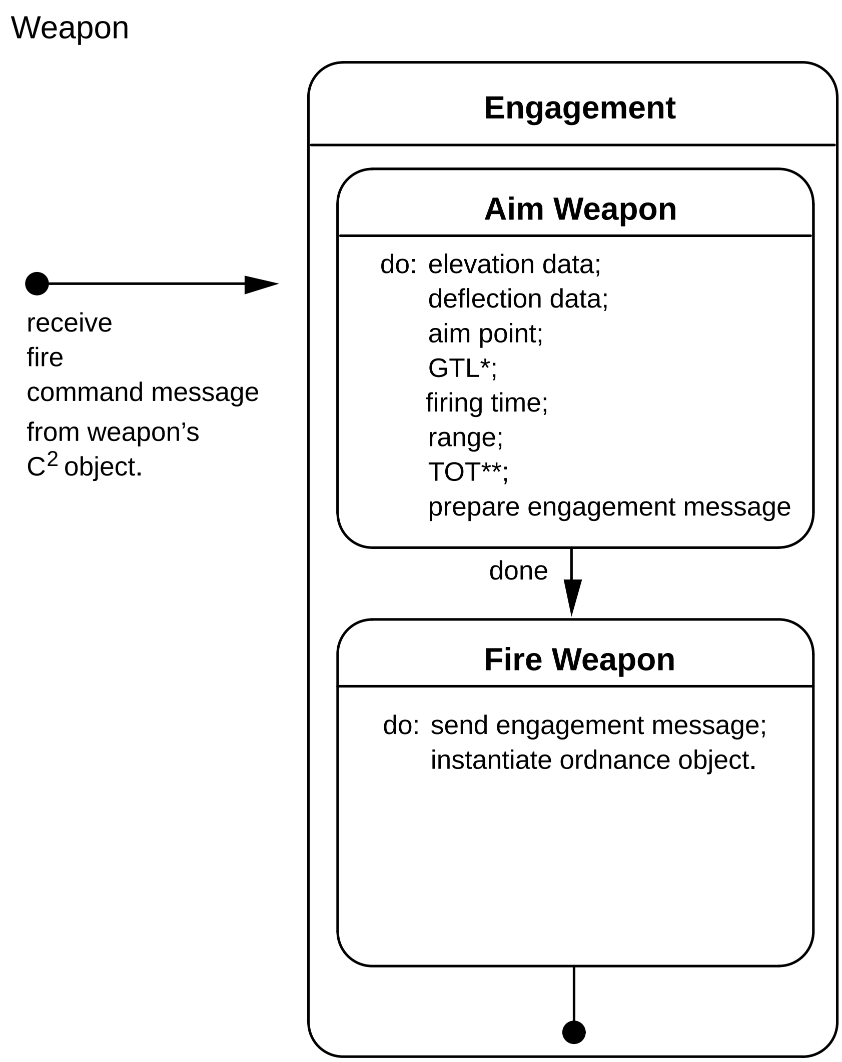
* GTL(D) = Modified gun-target-line to include deflection caused by relative speed of object and cross-wind factors

Figure D-74. Data flow diagram for Aim Weapon, Execute Small Arms Direct Fire engagement.



*Upon receipt of engagement message, weapon object activates entity; receiving fire resulting in a BDA message being sent to the weapon C^2 object.

Figure D-75. Data flow diagram for Fire Weapon, Execute Small Arms Direct Fire engagement.

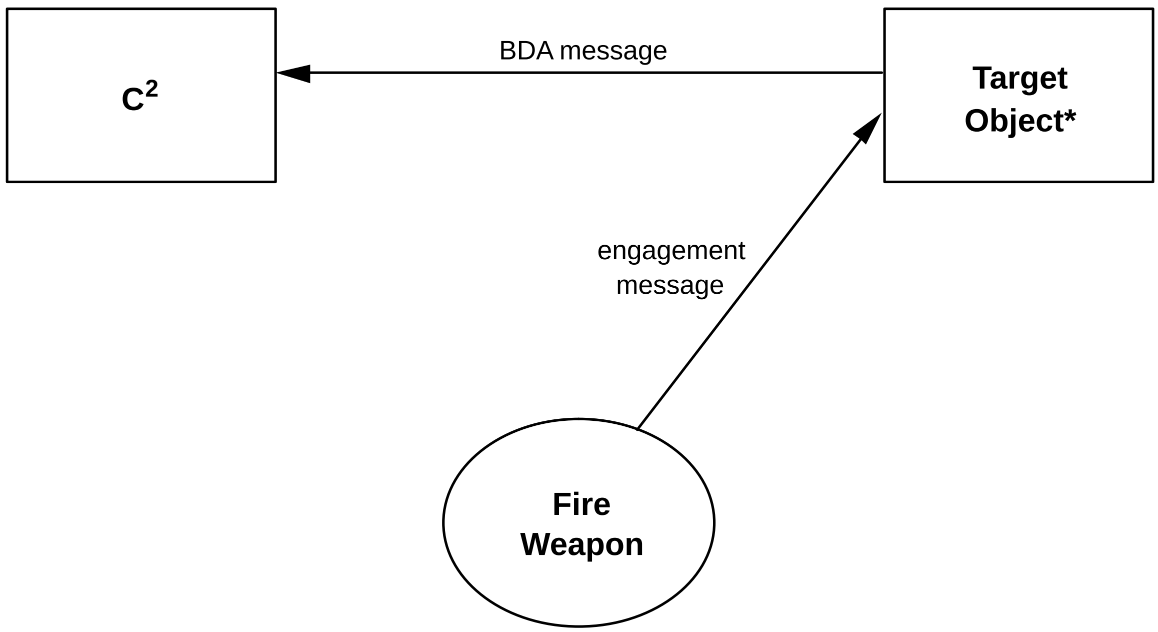


* GTL: Gun-Target-Line can be in degrees or mils, magnetic or UTM grid.

** TOT: Time-on-Target

Figure D-76. State diagram for Execute Small Arms Direct Fire engagement.

Weapon



* Virtually any physical object can be a target object (tree, bridge, soldier, tank). Refer to: State Diagram for Receiving Fire.

Figure D-77. Data flow diagram for Fire Weapon, Execute Small Arms Direct Fire engagement.

Weapon

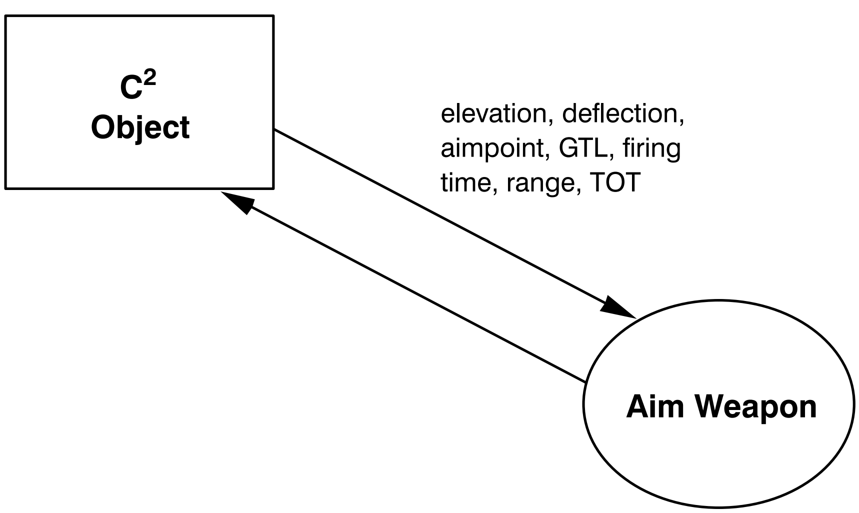


Figure D-78. Data flow diagram for Aim Weapon, Execute Small Arms Direct Fire engagement.

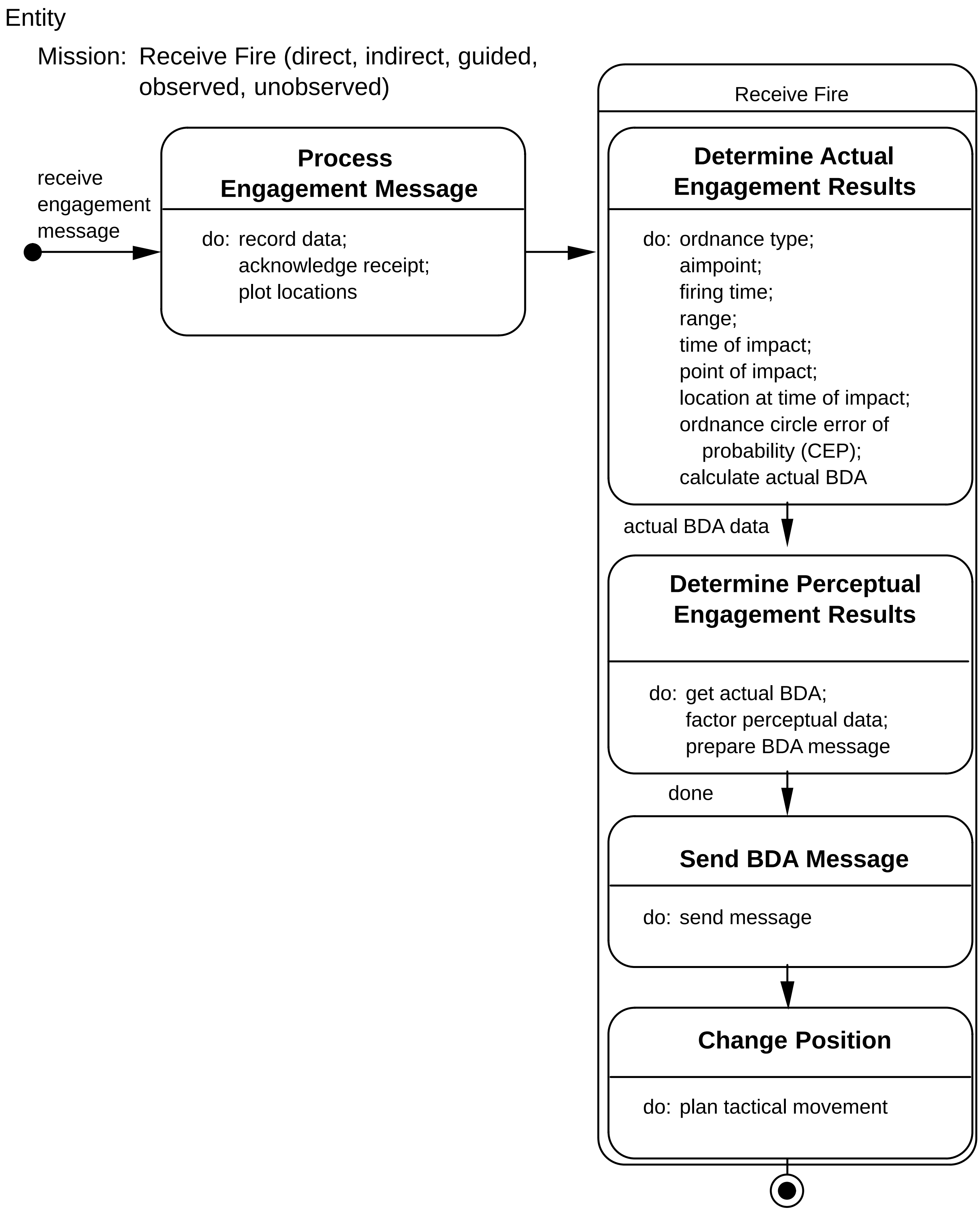
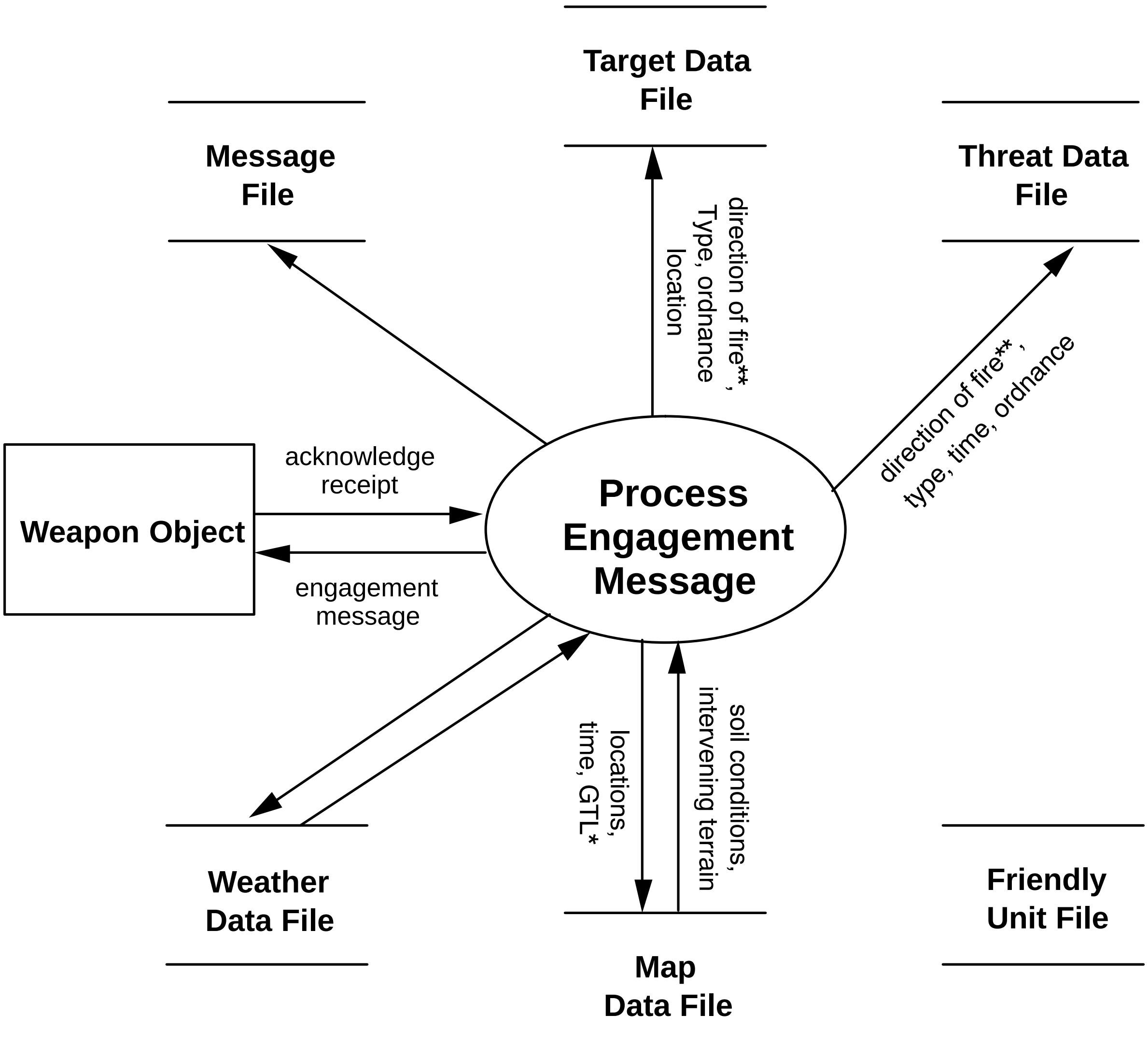
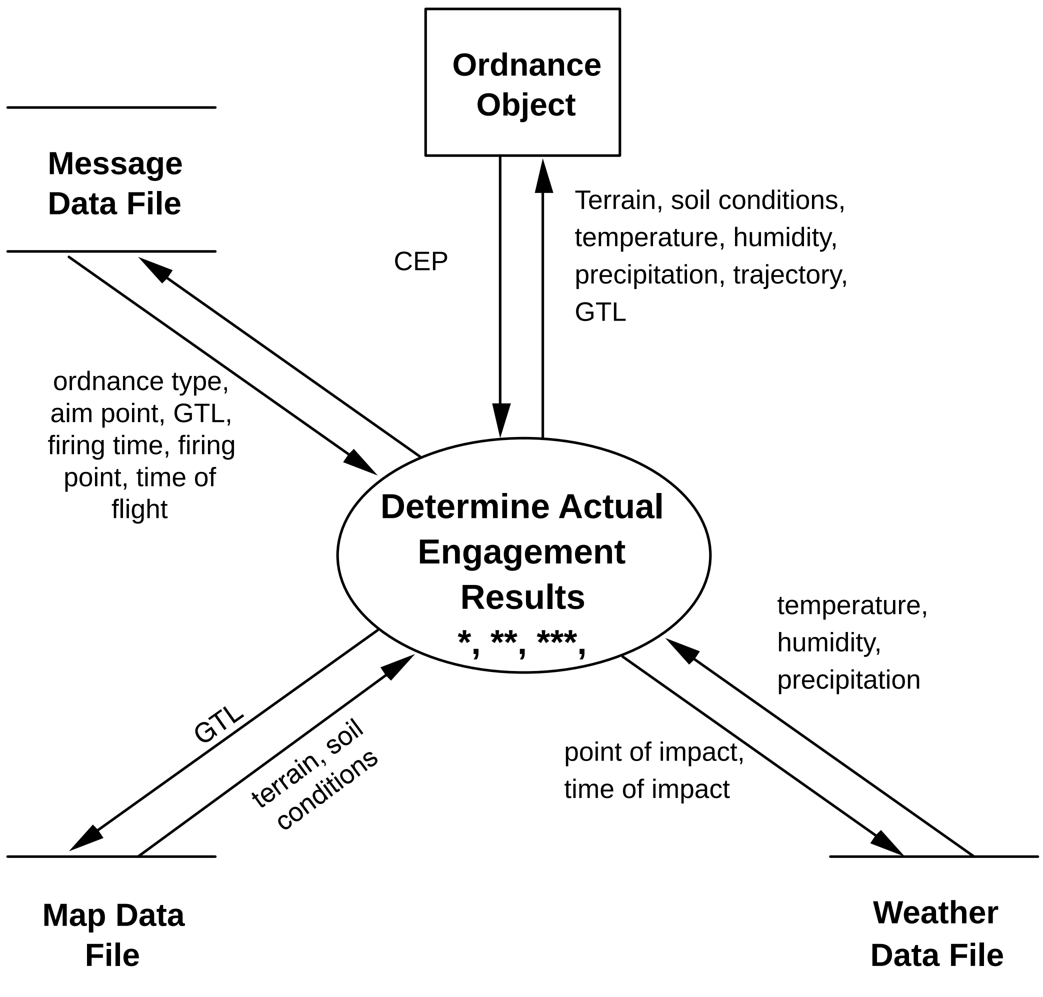


Figure D-79. State diagram for Receiving Fire (direct, indirect, guided, observed, unobserved).



*GTL: Gun-target-line
**Direction of fire is merely back-azimuth of GTL

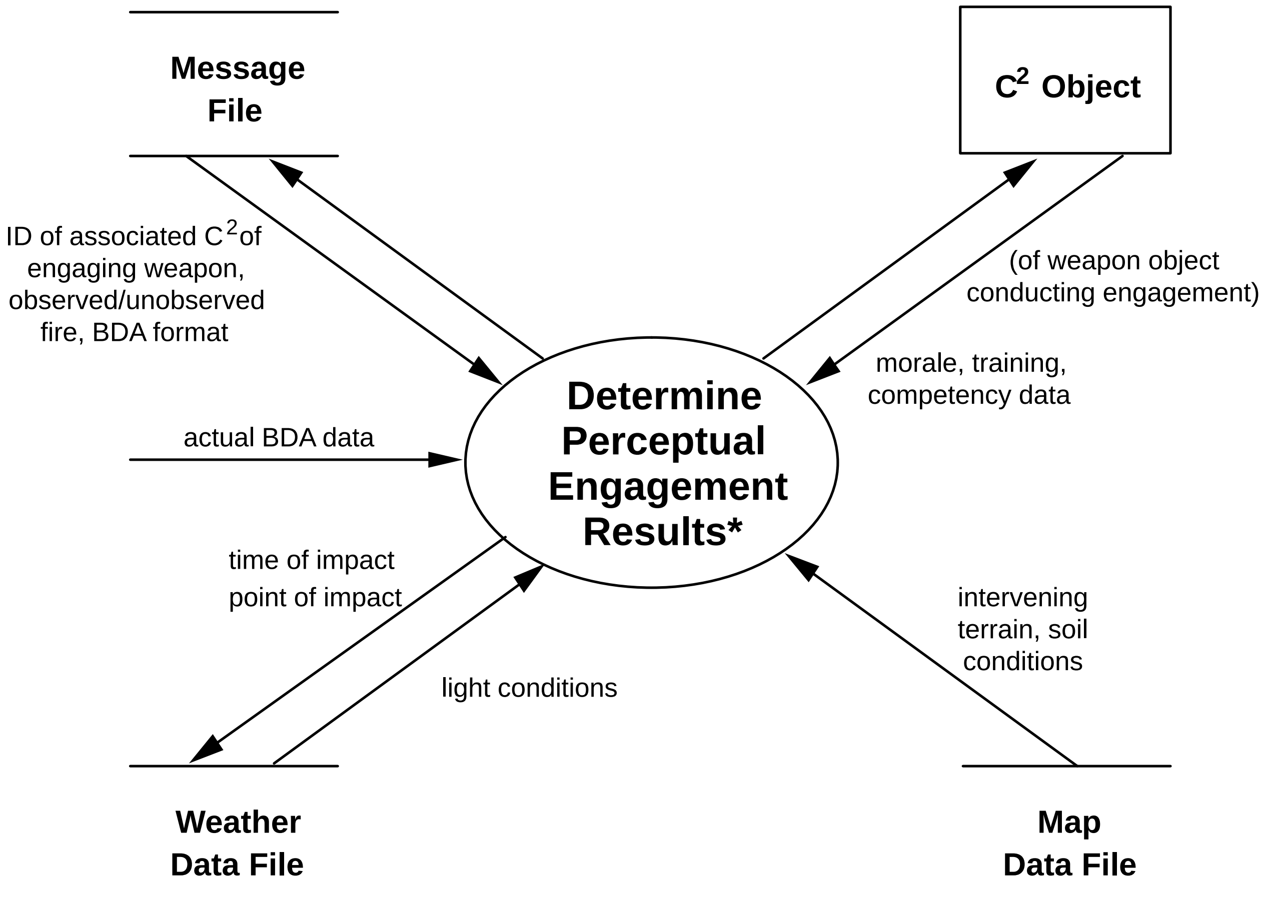
Figure D-80. Data flow diagram for Process Engagement Message, Receiving Fire.



*   Uses gun target line (GTL) to determine whether intervening terrain provided cover at time of impact
** Calculates time of impact
*** Compares own location at time of impact to location of the impact, using a CEP formula, determines whether damaged or not

Each entity must “know” its own vulnerability to types of ordnance by using a look-up table. i.e., a human object would “look up” its vulnerability to a single bullet at the same time and location as it was ... perhaps roll a die to see if it was “killed,” wounded, etc.   <u>But</u> a tank object would know it was impervious to a single bullet or other small arms ordnance.

Figure D-81. Data flow diagram for Determine Engagement Results, Receiving Fire.



* Light, weather, and terrain are used to determine if perceptual results can be calculated, and how extensive. If point of impact can be observed, true BDA is sent. If not observed or with high obscuration (smoke, distance, intervening terrain), BDA are randomly degraded.

Figure D-82. Data flow diagram for Determine Perceptual Engagement Results, Receiving Fire.

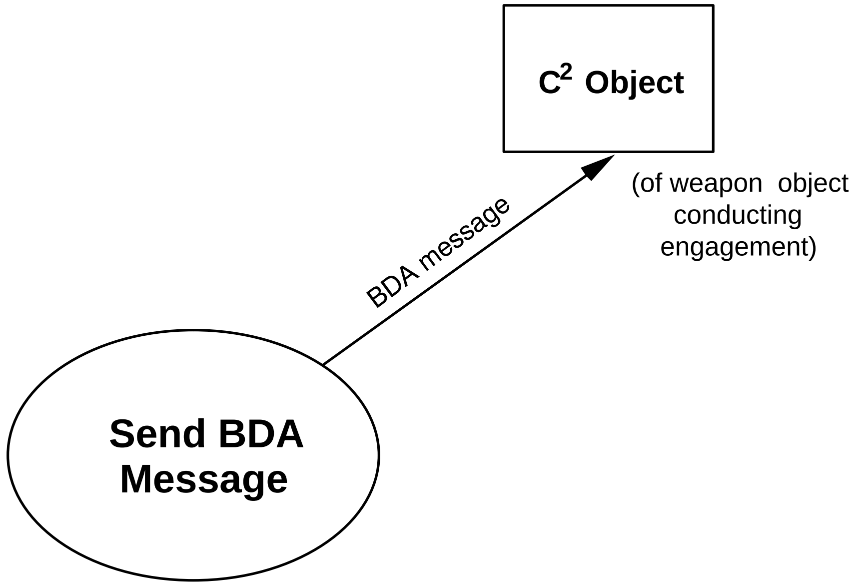


Figure D-83. Data flow diagram for Send BDA Message, Receiving Fire.

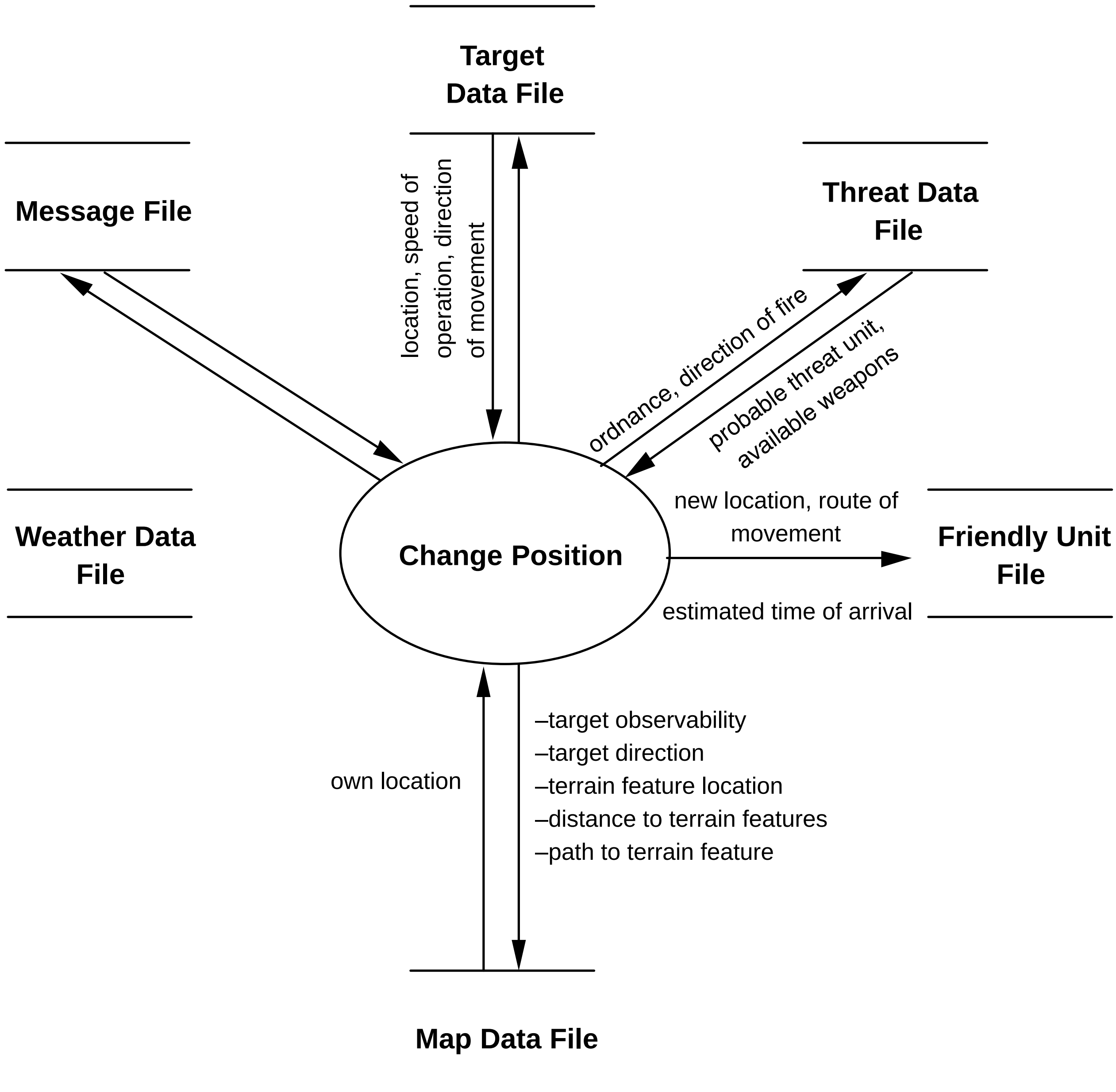


Figure D-84. Data flow diagram for Change Location, Receiving Fire.

Equipment
Sensor
Active
Radar

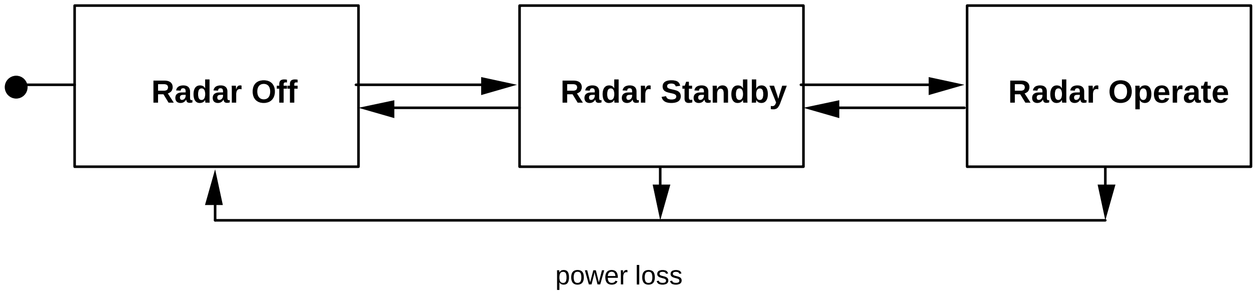


Figure D-85. State diagram for the active radar.

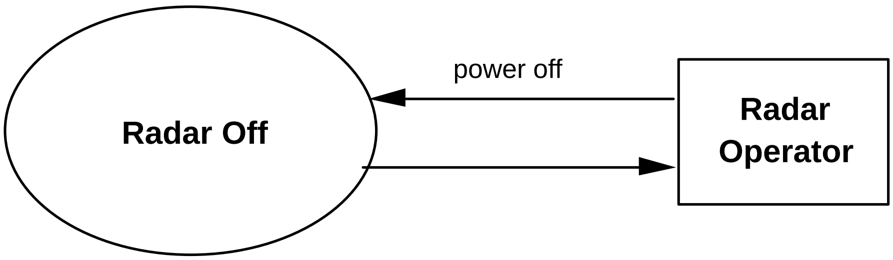


Figure D-86. Data flow diagram for the Radar Off state.

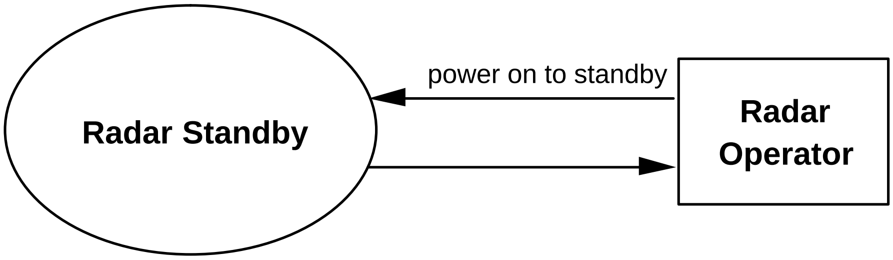


Figure D-87. Data flow diagram for the Radar Standby state.

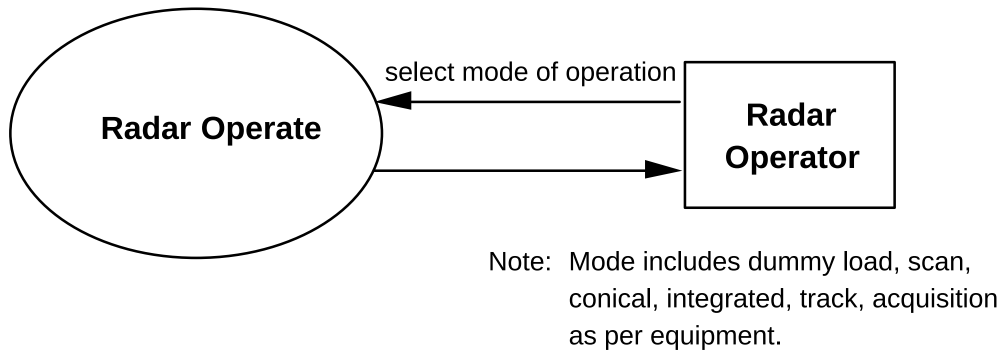


Figure D-88. Data flow diagram for the Radar Operate state.

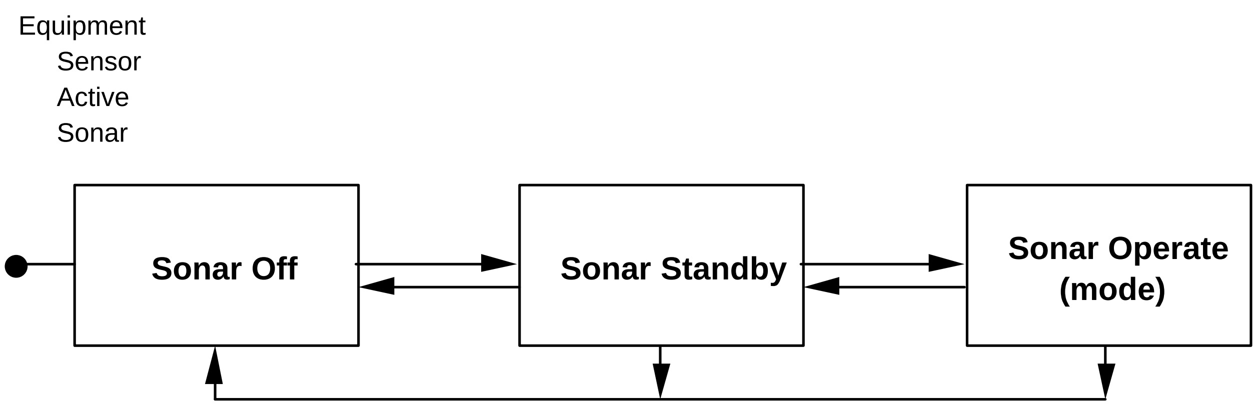


Figure D-89. State diagram for the active sonar.

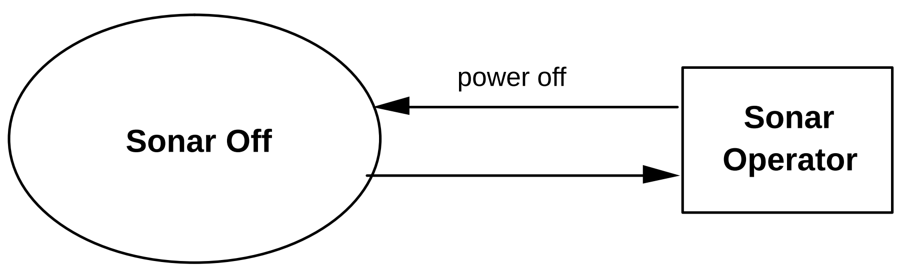


Figure D-90. Data flow diagram for the Sonar Off state.

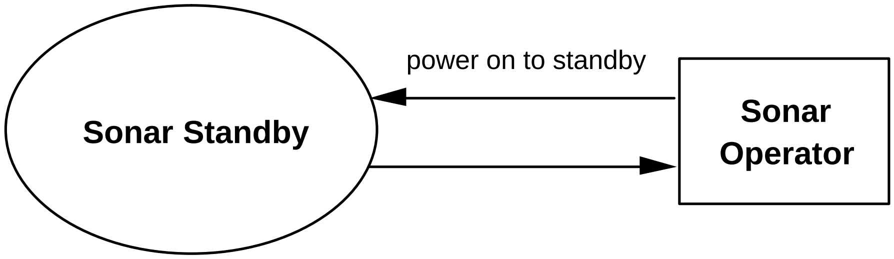
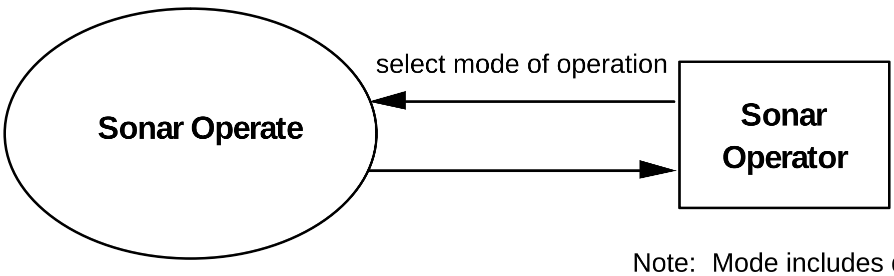


Figure D-91. Data flow diagram for the Sonar Standby state.



Note: Mode includes direct path, bottom bounce or convergence zone.

Figure D-92. Data flow diagram for the Sonar Operate state.

Equipment
  Sensor
  Active
  Viscom (Visual Communications, Signal Light, Laser)

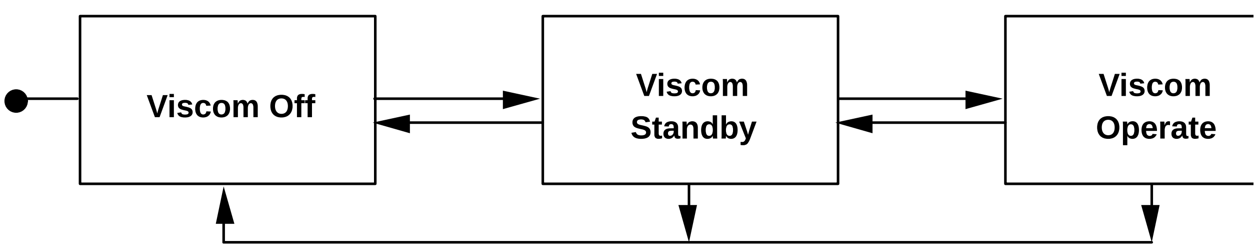


Figure D-93. State diagram for the active viscom.

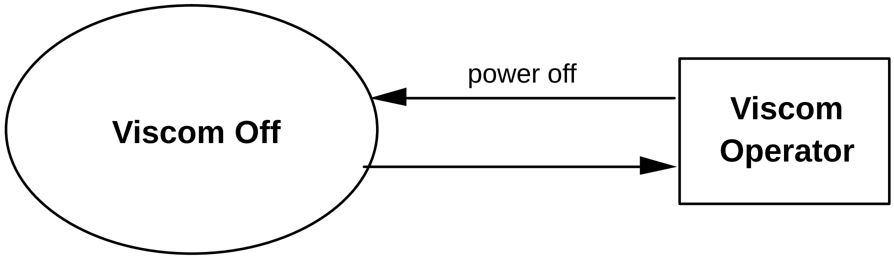


Figure D-94. Data flow diagram for the Viscom Off state.

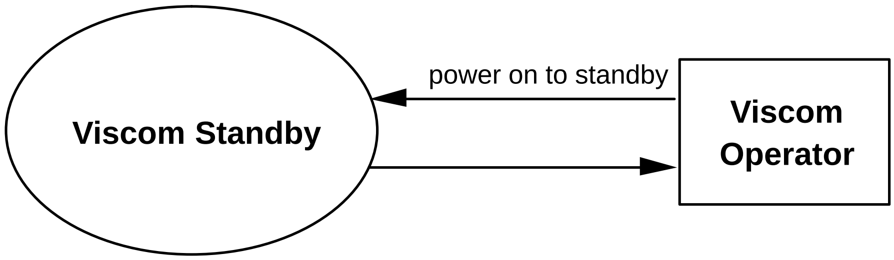


Figure D-95. Data flow diagram for the Viscom Standby state.

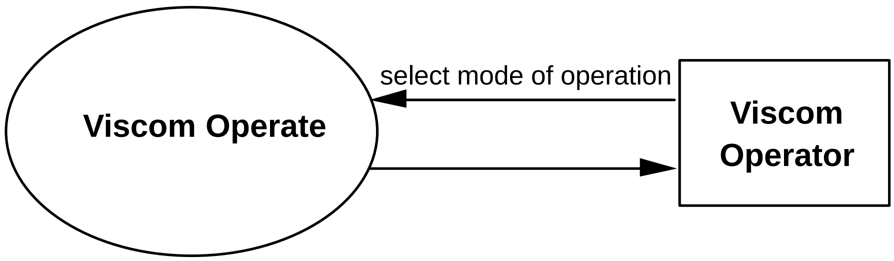


Figure D-96. Data flow diagram for the Viscom Operate state.

Note: Prior to proceeding with the mission the pilot must confirm that the described systems required for the mission are operating properly (i.e., if AEW/C – Airborne Early Warning and Control aircraft (E–2C/E–3C) are required for the mission they must be operating).

do: elevation data;
deflection data;
aim point;
GTL*;
firing time;
range;
TOT**;
prepare engagement message

APPENDIX E: GLOSSARY

A^2C^2	Army Airspace Command and Control
AAW	Anti-Aircraft Warfare
ABCCC	Airborne Battlefield C^2 Center
ACC	Air Component Commander
ACINT	Acoustic Intelligence
ADA	Air Defense Artillery
AFAC	Airborne Forward Air Controller
AI	Air Interdiction
ALCC	Airlift Control Center
ALCE	Airlift Control Element
AMW	Amphbious Warfare
AO	Area of Operation
AOO	Air Operations Orders
APOD	Airport of Debarkation
ARFOR	Army Forces
ARG	Amphibious Ready Group
ARPA	Advanced Research Projects Agency (DoD)
ASOC	Air Support Operations Center
ASUW	Air Support Operations Center
ASW	Anti-Surface Warfare
ATO	Air Tasking Order
ATP	Ammunition Transfer Point
AWACS	Airborne Warning and Control System
AWSIM	Advanced Weapon System Information Management
BCA	Bomb Damage Assessment
BCE	Battlefield Coordination Element
C^2	Command and Control
C^2RM	Command and Control Reference Model
C^3I	Command, Control, Communications and Intelligence
C^4I	Command, Control, Communications, Computers and Intelligence
CA	Counter Air
CAD	Computer Aided Design
CAM	Computer Aided Manufacturing
CAS	Close Air Support
CCIR	Commander’s Critical Information Requirements
CCT	Combat Control Element
CECOM	U.S. Army Communications/Electronics Command
CEP	Circle Error of Probability
CEWI	Combat Electronic Warfare Intelligence
CFA	Covering Force Area
CID	Combat Intelligence Division
CINC	Commander-in-Chief
CINCPACFLT	Commander-in-Chief U.S. Pacific Fleet
CJTF	Commander Joint Task Force
CLIPS	C Language Production System

CLOS	Common Lisp Object System
CM	Configuration Management
CMD GP MEB	Commander Group Marine Expeditionary Brigade
COA	Course of Action
COFM	Correlation of Forces and Means
COMCARGRU	Commander Carrier Group
COMINT	Communications Intelligence
COMMZ	Communications Zone
CONUS	Continental United States
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off-the-Shelf
CRC	Control and Reporting Center
CRP	Control and Reporting Post
CSR	Controlled Supply Rates
CVN	Nuclear Carrier
CWM	Composite Warfare Model
DAS	Defensive Air Support
DEEM	Dynamic Environmental Effects Model
DF	Defense Force
DIS	Distributed Interactive Simulation
DISCOM	Division Support Command
DISUM	Division Summary
DIVARTY	Divisional Artillery
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DS	Direct Support
DSI	Defense Simulation Internet
EA	Engagement Area
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EMCON	Emissions Control
ENSCE	Enemy Situation Correlation Element
ESM	Electronic Support Measures
EW	Electronic Warfare
FAARP	Forward Area Arming and Refueling Points
FAC	Forward Air Controller
FACP	Forward Air Control Post
FASCAM	Family of Scatterable Mines
FEBA	Forward Edge of Battle Area
FF	Fast Frigate (USN Ship Designation)
FFG	Guided Missile Frigate (USN Ship Designation)
FLOT	Front Line of Troops
FORSTAT	Force Status Report
FRAGO	Fragmentary Order
FSB	Forward Support Battalion

FSCL	Fire Support Coordination Line (Army, Air Force)
FSK	Frequency Shift Keying
CACC	Ground Attack Control Center
GCI	Ground Control Intercept
GOTS	Government Off-the-Shelf
GRREG	Graves Registration Points
GS	General Support
GS/R	General Support/Receiving
GSR	General Support Reinforcing
HCI	Human–Computer Interaction
HF	High Frequency
HHC	Headquarters/Headquarters Company
HMH	Marine Heavy Helicopter Squadron
HMLA	Light Attack Helicopter Squadron
HN	Medium Helicopter Squadron
HN	Host Nation
Hq	Headquarters
IAC	Information Analysis Center
IDL	Interface Definition Language
IEW	Intelligence and Electronic Warfare
IFV	Infantry Fighting Vehicle
IMINT	Imagery Intelligence
INT	Inteligence
INTSUM	Intelligence Summary
ISO OSI	International Standards Organization's Open Systems Interface
JAAT	Joint Air Attack Team
JCS	Joint Chiefs of Staff
JFNCC	Joint Forces Naval Component Command
JOPES	Joint Operational Planning and Execution System
JSIMS	Joint Simulation System
JTF	Joint Task Force
JTF–ATD	Joint Task Force–Advanced Technology Demonstration
JWID	Joint Warrior Interoperability Demonstration
JWSOL	Joint Warfare Simulation Object Library
KADS	Knowledge Acquisition and Design Structuring
KRSL	Knowledge Representation Specification Language
LIC	Low-Intensity Conflict
LOC	Lines of Communication
LOSREP	Line of Sight Report
LP	Listening Posts
LRSU	Long Range Surveillance Units
M&S	Modeling and Simulation
MALSFW	Marine Aviation Logistics Squadron (Fixed Wing)

MALSRW	Marine Aviation Logistics Squadron (Rotary Wing)
MARS	Multiwarfare Assessment and Research System
MASINT	Measurements and Signature Intelligence
MBA	Main Battle Area
MEB	Marine Expeditionary Brigade
METT-T	Mission, Enemy, Troops, Terrain, and Time
MIJI	Meaconing, Intrusion, Jamming and Interference
MIW	Mine Warfare
MODSIN	A programming language
MOS	Miltary Operational Specialty
MP	Military Police
MWSSFW	Wing Support Squadron Fixed Wing
MRB	Model Request Broker
NALE	Naval and Amphibious Liaison Element
NBC	Nuclear/Biological/Chemical
NCA	National Command Authority
NCCOSC	Naval Command, Control and Ocean Surveillance Center
NEO	Non-Combatant Evacuation Operation
NETT	New Equipment Training Team
NGFS	Naval Gun Fire Support
NRaD	Naval Command, Control and Ocean Surveillance Center, RDT&E Division
NSS	Naval Simulation System
NSW	Navy Special Warfare
NUDET	Nuclear Detonation
OAS	Offensive Air Support
OCOKA	Observation and Fields of Fire, Cover and Concealment, Objectives, K—Key Terrain, A—Avenues of Approach
ODBMS	Object Oriented Database Management System
OLE	Object Linked Embedding
OMWG	Object Management Working Group
OO	Object Oriented
OOA	Object Oriented Analysis
OOD	Object Oriented Design
OP	Observation Posts
OPAREA	Operational Area
OPLANS	Operational Plans
OPORD	Operational Order
OPREP	Operational Report
OPSEC	Operations Security
ORB	Object Request Broker
OT	Object Technology
PA	Public Affairs
PIM	Position of Intended Movement
PIR	Priority Information Requirements
PIREP	Pilot Inflight Report

POL	Petroleum, Oil, and Lubricants
PVO	Operational planning process
R	Reinforcing
RAD	Rapid Application Development
RCT	Regimental Combat Team
RDT&E	Research, Development, Test & Evaluation
REINF	Reinforced
RESA	Research, Evaluation and Systems Analysis Facility
ROE	Rules of Engagement
RSR	Required Supply Rates
SAFOR	Semi-Automated Forces
SAM	Surface-to-Air Missile
SCUDS	Soviet short range surface-to-surface missiles
SIGINT	Signals Intelligence
SIGSEC	Signal Security
SITREP	Situation Report
SLOC	Sea Lines of Communication
SME	Subject Matter Expert
SOF	Special Operating Forces
SOP	Standard Operating Procedure
SPIREP	Special Purpose Intelligence Report
SPOD	Seaport of Debarkation
SQT	Skill Qualification Testing
SSN	Submarine, Nuclear
STOW	Synthetic Theater of War
STW	Strike Warfare
TACC	Tactical Air Control Center
TACOP	Tactical Air Control Post
TACP	Tactical Air Control Party
TACREP	Tactical Report
TACRON	Tactical Air Control Squadron
TAF	Tactical Air Force
TCP	Traffic Control Point
TCP/IP	Transport Control Protocol/Internet Protocol
TESS	Tactical Environmental Support System
T/O	Table of Organizations
TOW	Tube Launched, Optically Tracked, Wire Guided (Missile)
TPFDL	Time-Phased Force Deployment List
TRADOC	Training and Doctrine Command
U&S	Unified and Specified
UHF	Ultra High Frequency
UJTL	Universal Joint Task List
USCENTCOM	U.S. Central Command
USMTF	United States Message Text Format
UTM	Universal Transverse Mercator

V&V	Verification and Validation
VHF	Very High Frequency
VLF	Very Low Frequency
VM	Marine Aerial Refueler Transport Squadron
VMA	Marine Attack Squadron
VMFA	Marine Fighter Attack Squadron
VMG	Marine Observation Detachment
VTDP	Target Vector Designation Points
VV&A	Verification, Validation and Accreditation
WOC	Wing Operations Center
WWMCCS	Worldwide Military Command and Control System

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13. ABSTRACT *(Maximum 200 words)*

The Joint Warfare Simulation Object Library (JWSOL) produced a joint warfare simulation requirements document in 1994. This second document provides the object-oriented, hierarchical design, or taxonomy, that embodies the functionality specified in the requirements document. The purpose of JWSOL has been to demonstrate the feasibility of the concept of a basic set of objects within a single joint service repository, such that the objects are owned and maintained by the separate Services but are available within one virtual repository for reuse by all, thereby eliminating redundancy and improving accuracy and currency. Future work will concentrate on iterative coding and on redefining requirements.

The JWSOL project and its products have provided the initial baseline of requirements and design for other programs, including the Joint Program Office for the Joint Simulation System. JWSOL products provide a means by which others interested in warfare simulation can make use of existing design and code, eliminating costly duplication of effort.

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